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Resilient Renewable Energy Microgrids

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NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Overview

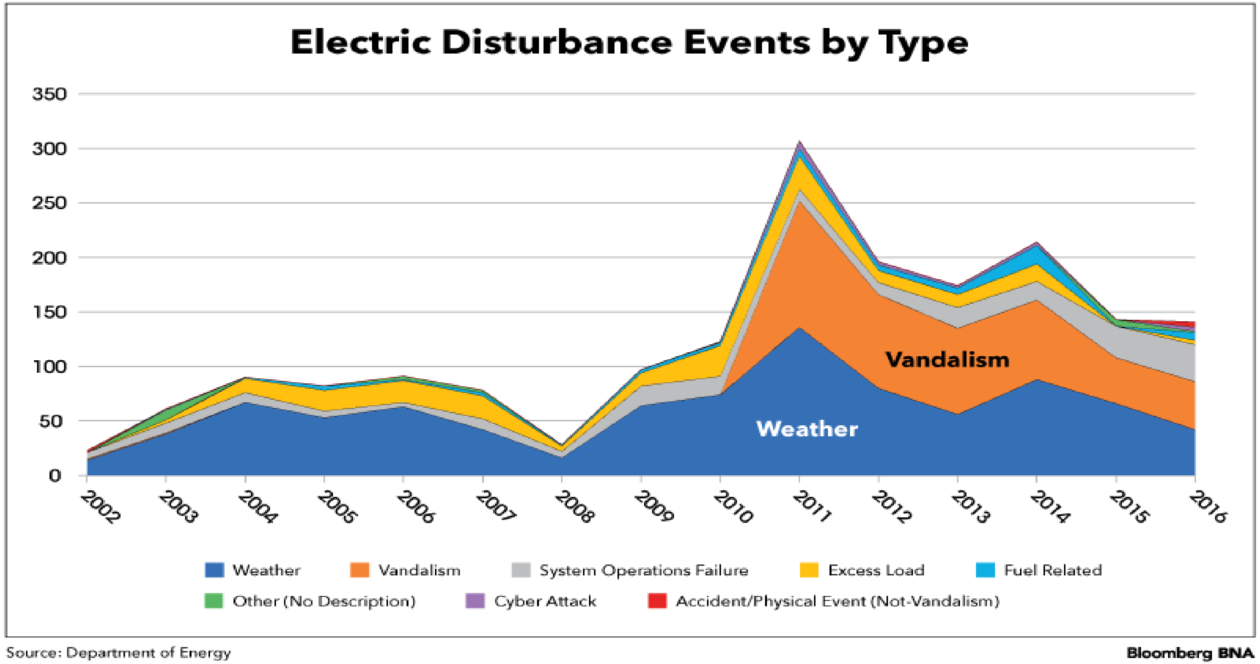
Why consider RE-battery-diesel hybrid microgrids for backup power?

Estimating economic savings

Quantifying the resiliency gain

Where will this work?

Power Outages are Increasing



The United States has seen an increase in the number of high-impact, high-cost natural disasters—seven of the ten costliest storms in U.S. history have occurred in the last ten years.

Existing Backup Power Is Insufficient In Some Cases

On-site diesel fuel supplies typically only last 1-2 days

Regulatory requirements may limit on-site fuel storage

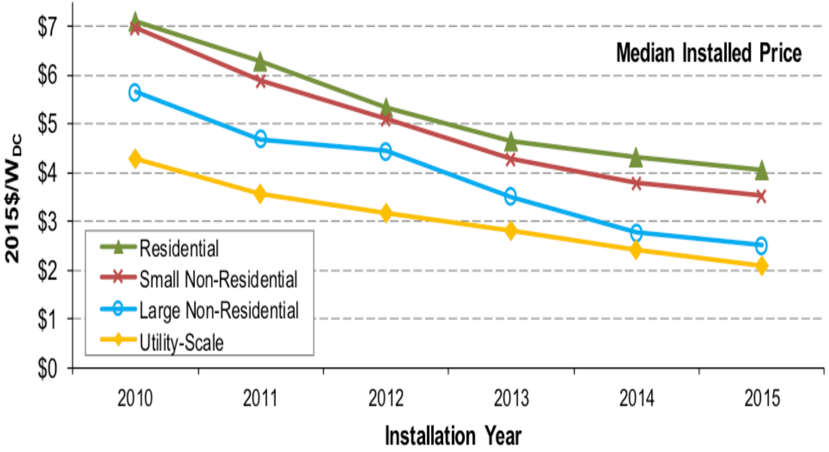
Diesel fuel re-supply is vulnerable

- Disasters may damage fuel supply chain or fuel may be diverted to higher priority needs

Source: NREL Pix 24490

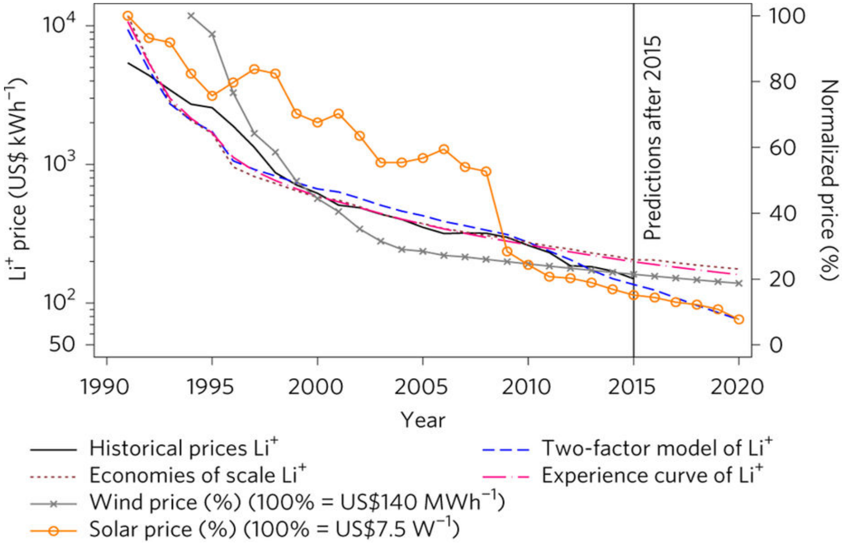
Solar and Storage Costs are Falling

Solar



Source: Lawrence Berkeley National Laboratory

Storage

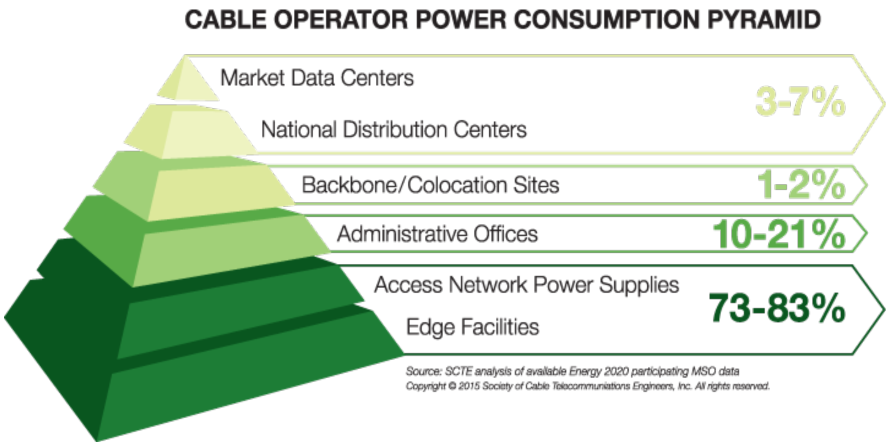


Source: Nature Energy

The Cable Industry is Striving to Lower Energy Consumption, Cut Energy Costs, and Reduce Dependence on the Grid

SCTE Energy 2020 Goals

- Reduce energy intensity by 15% year on year
- Reduce energy costs by 25% on a unit basis
- Reduce grid dependency by 10%
- Optimize technical facilities and datacenters footprint by 20%



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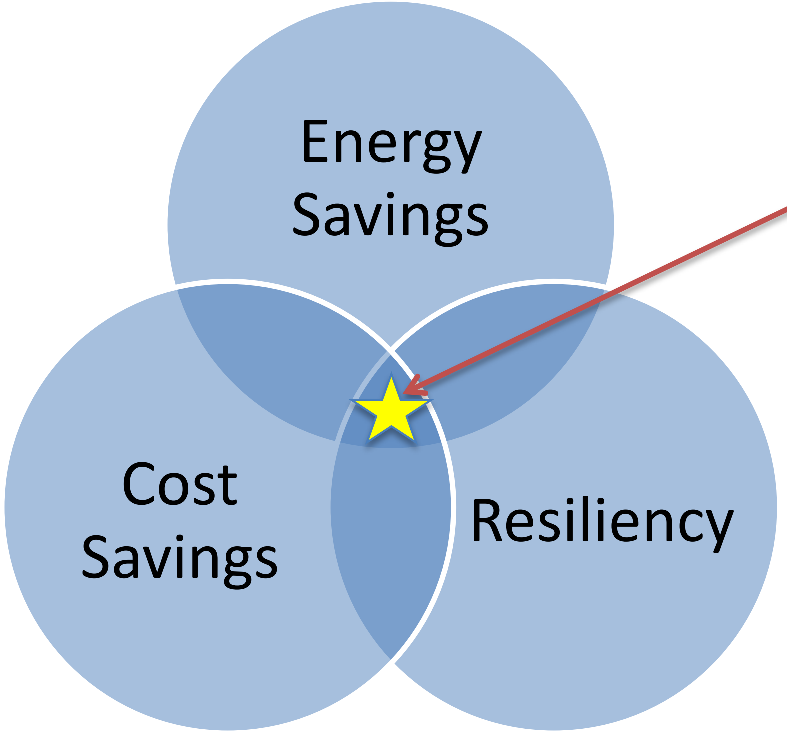


Why consider RE microgrids?

The triple bottom line.

Diesel generators alone provide resiliency.

RE/storage/diesel hybrid microgrids provide resiliency + energy savings + cost savings.

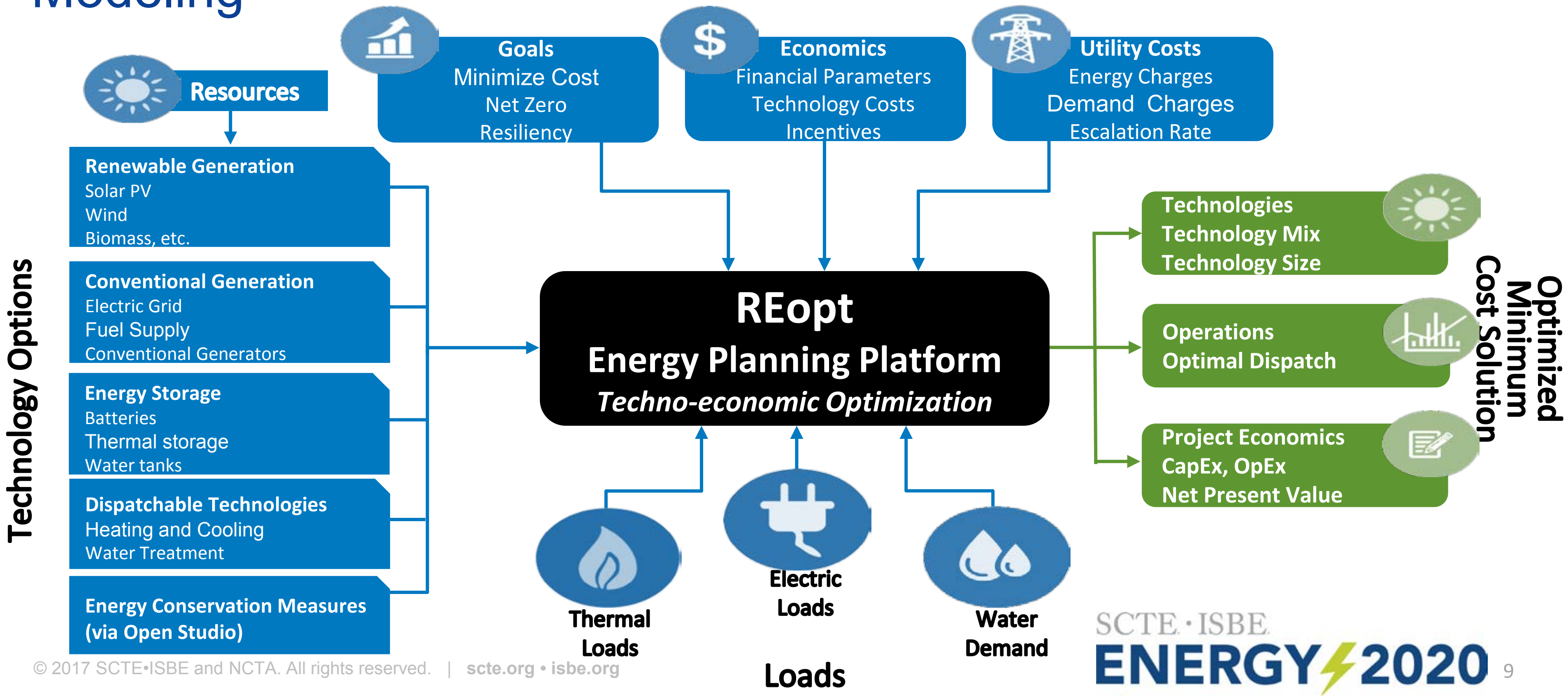
Case Study: Southern California Telecommunications Facility

Multi-use facility includes administrative offices, warehouse, production studio, technology center, customer service center, and hub site delivering cable services to surrounding community

- Average load 150 kW, ranging from 120-250 kW; critical load 155 kW
- Annual energy use: 1400 MWh
- Annual energy cost: $250,000
- 300 kW of backup diesel generation

Utility Rate Tariff		
Fixed monthly charge	$453.25/meter	
Facility demand charge	$19.38/kW	
June-September	**Energy Charge ($/kWh)**	**Demand Charge ($/kW)**
Noon-6 p.m., weekdays	0.15856	15.51
8 a.m.-noon, 6 p.m.-11 p.m., weekdays	0.12541	3.05
All other hours	0.10878	0
October-May	**Energy Charge ($/kWh)**	**Demand Charge ($/kW)**
8 a.m.-9 p.m., weekdays	0.12156	0
All other hours	0.1131	0

Modeling

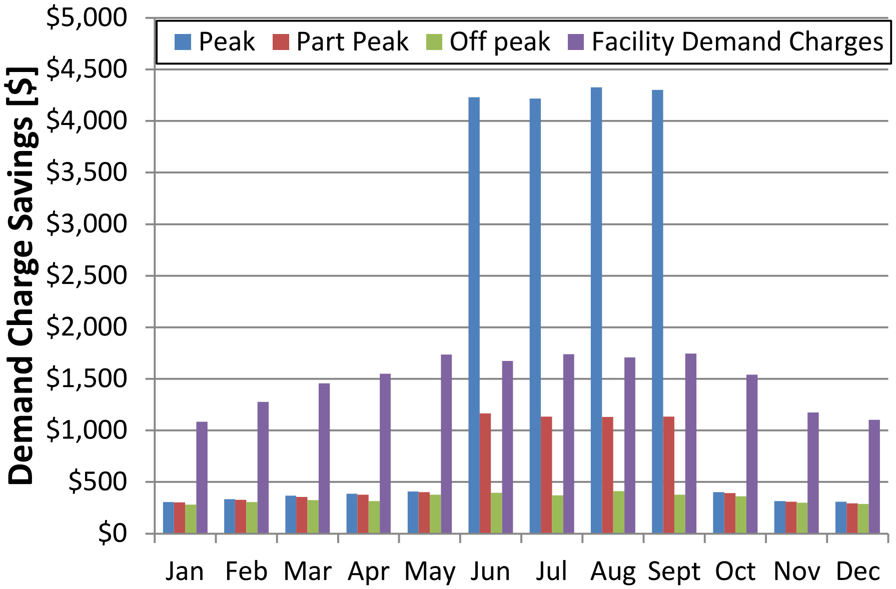

Resources
Goals
Minimize Cost
Net Zero
Resiliency
Economics
Financial Parameters
Technology Costs
Incentives
Utility Costs
Energy Charges
Demand Charges
Escalation Rate
Technology Options
Renewable Generation
Solar PV
Wind
Biomass, etc.
Conventional Generation
Electric Grid
Fuel Supply
Conventional Generators
Energy Storage
Batteries
Thermal storage
Water tanks
Dispatchable Technologies
Heating and Cooling
Water Treatment
Energy Conservation Measures
(via Open Studio)
REopt
Energy Planning Platform
Techno-economic Optimization
Technologies
Technology Mix
Technology Size
Operations
Optimal Dispatch
Project Economics
CapEx, OpEx
Net Present Value
Optimized
Minimum
Cost Solution
Thermal
Loads
Electric
Loads
Water
Demand
Loads

Assumptions

Input	Assumption
Analysis period	25 years
Ownership model	Third-party owned
Site discount rate	7%
Developer discount rate	10%
Corporate tax rate	35%
General inflation rate	0.1% per National Institute of Standards and Technology (NIST)
Utility cost escalation rates	0.1% per NIST
Incentives	30% Federal ITC for PV and battery, 5-year MACRS depreciation, $0.36/kWh SGIP
Net metering limit	1 MW
PV capital cost	$2.13/kW
PV O&M cost (includes 1 inverter replacement)	$0.02/W-year
Battery capital cost	$520/kWh plus $1000/kW
Battery replacement cost (year 10)	$200/kWh plus $200/kW
Solar resource	TMY2 solar data

Quantifying the Economic Benefit of Solar PV+Battery

Solar PV Size	845 kW
Battery Size	155 kW, 172 kWh
Developer Cost[a]	$2,450,000
Annual O&M	$16,900 /yr
% Renewable Energy	91%
Year 1 Savings	$42,000
Net Present Value	$519,000
Lifecycle Savings	18%



a. Includes PV, BESS, and site electrical work, BEFORE incentives are applied.

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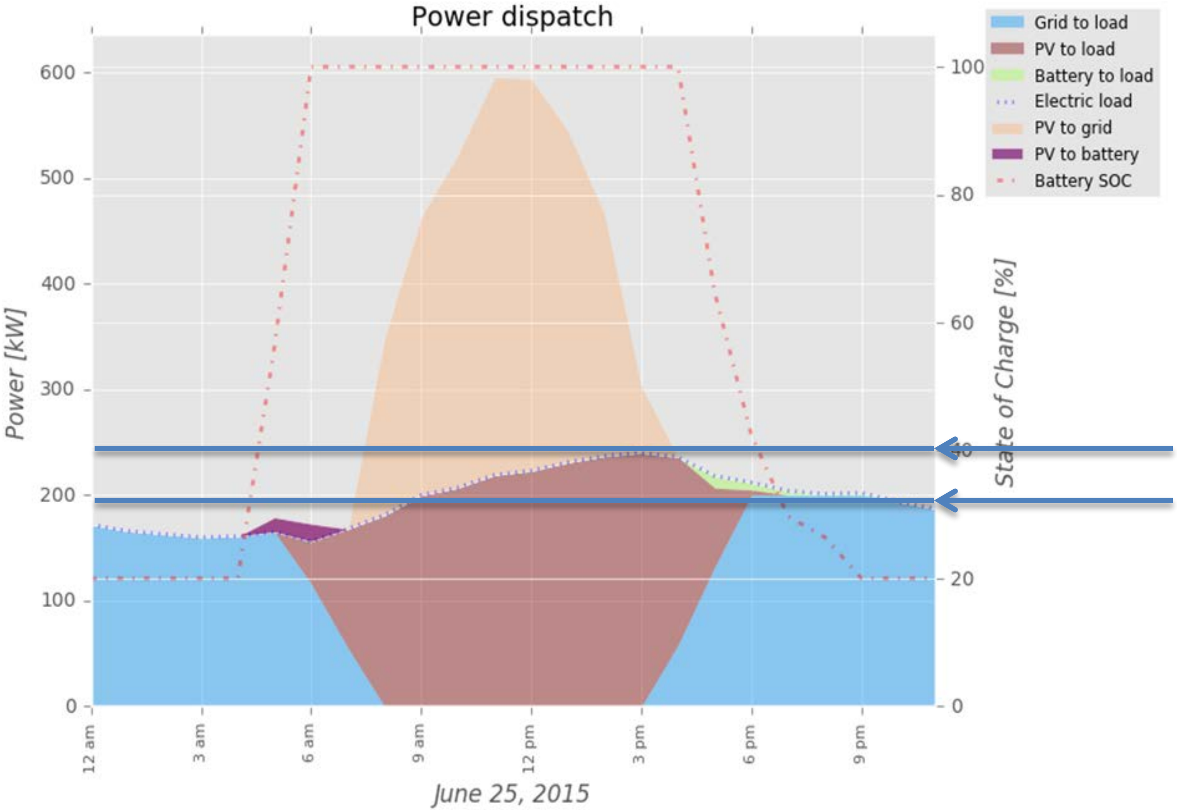

Example Day

Peak demand without solar+battery

Peak demand with solar+battery

50 kW reduction in peak

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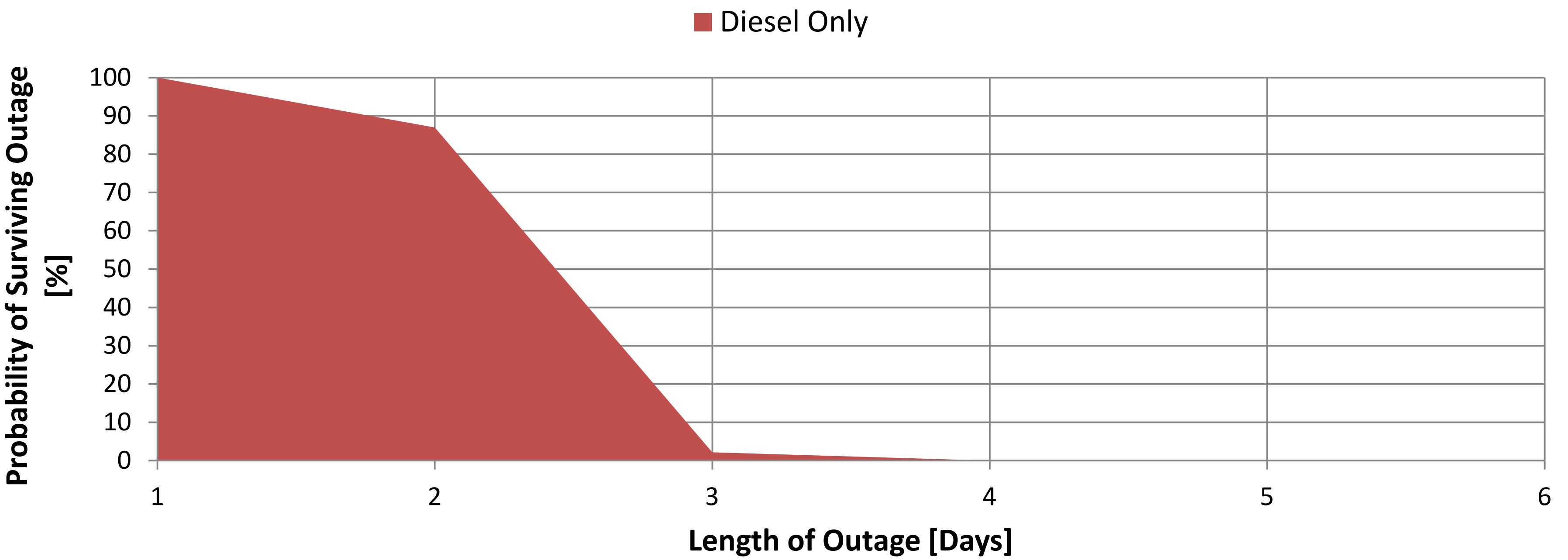
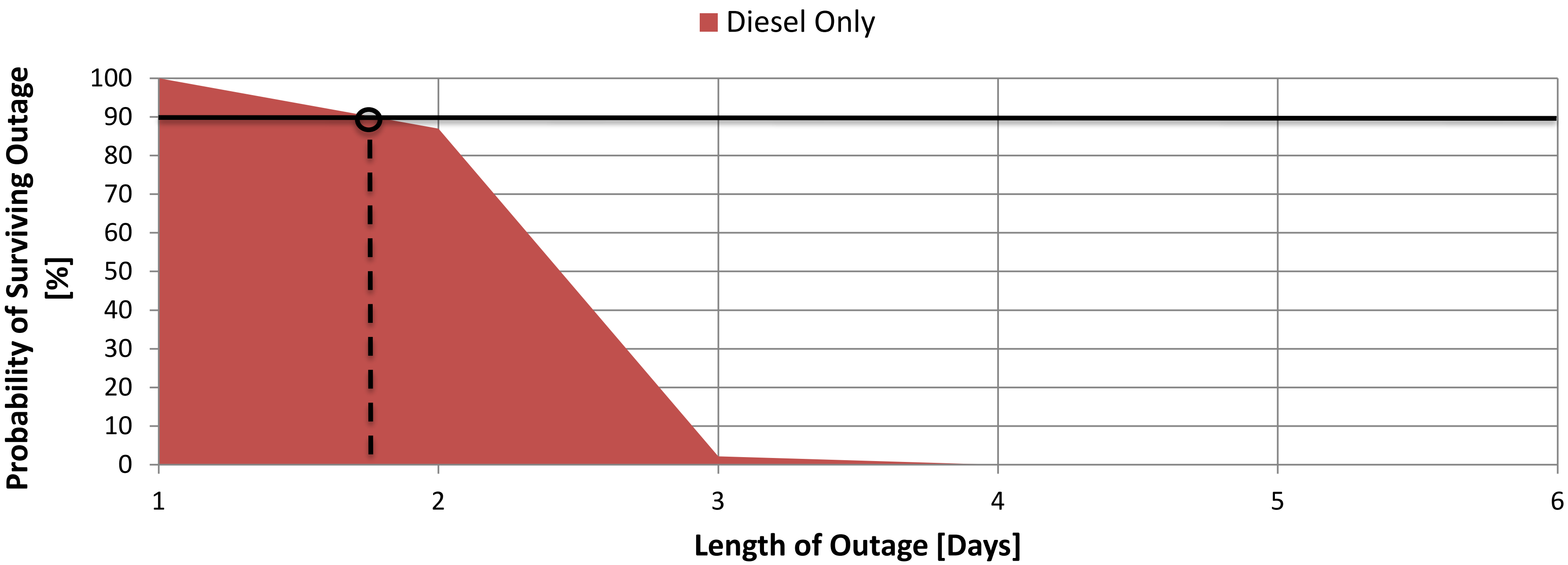
Quantifying the Resiliency Benefit of RE+Storage



Quantifying the Resiliency Benefit of RE+Storage



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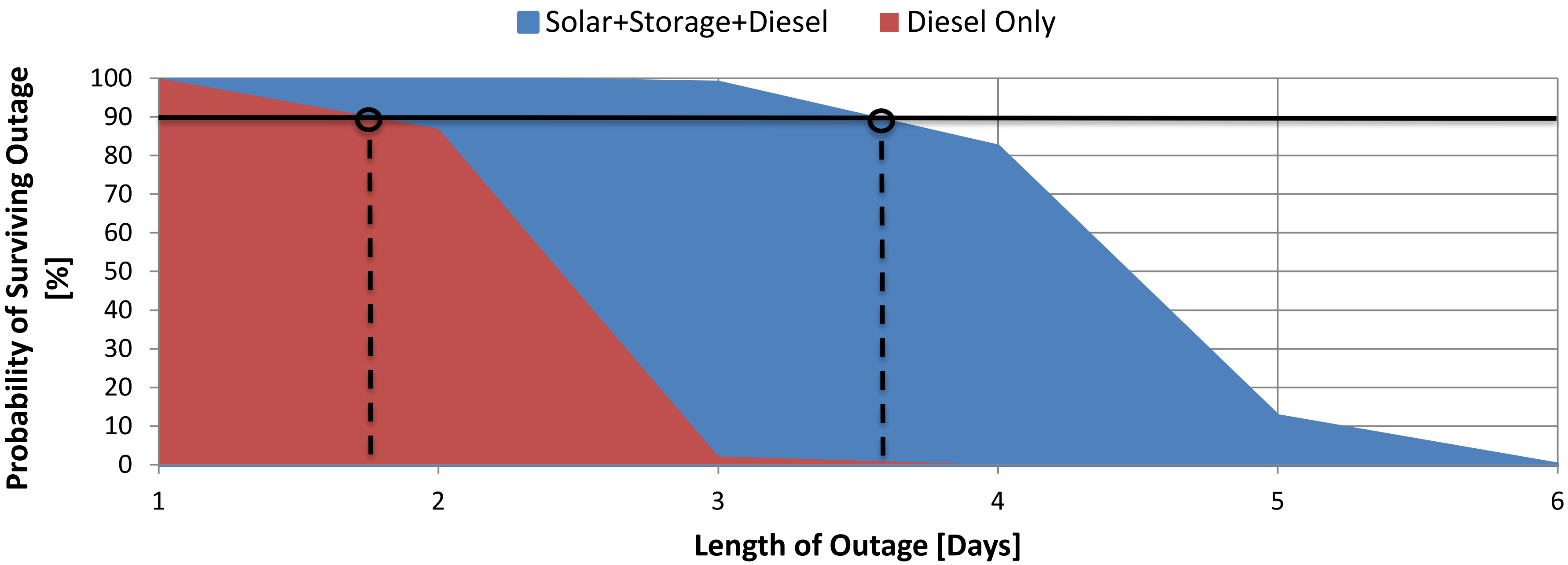

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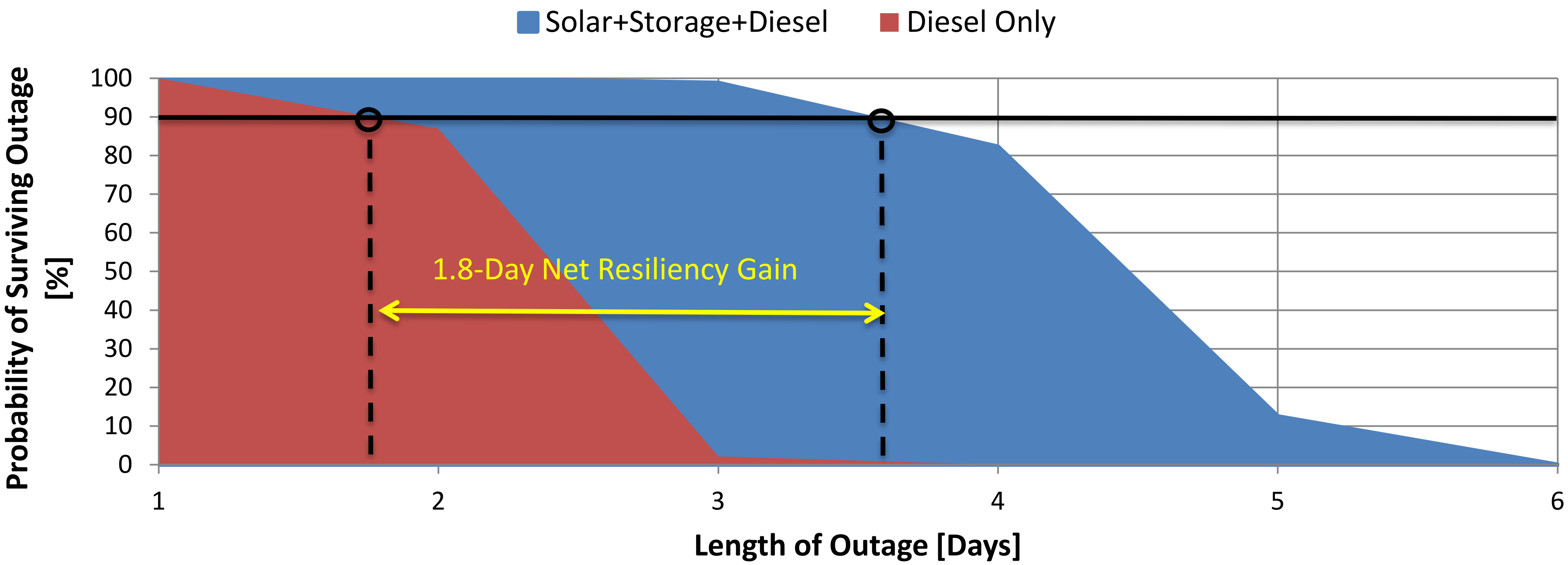

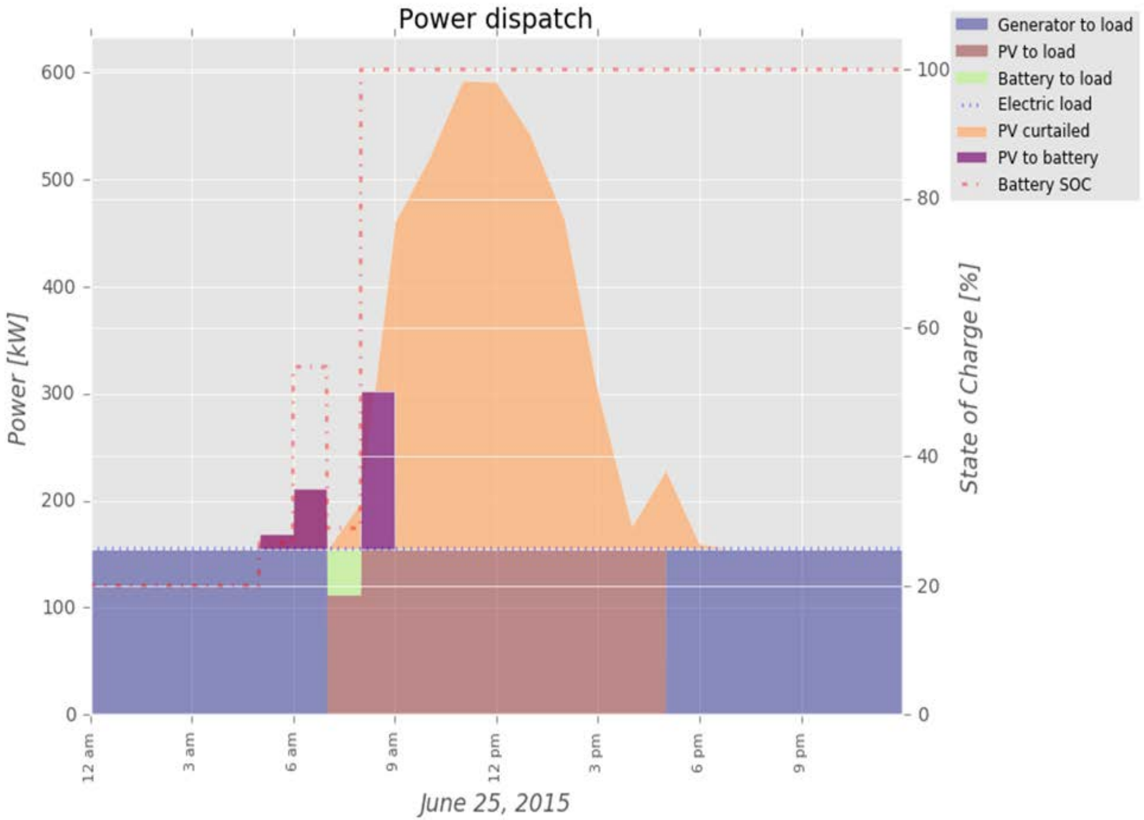

How it Works

Solar PV allows generator to turn off during daytime hours, extending diesel fuel supply

Battery provides backup during transition from diesel to solar and during cloudy times

After diesel fuel is exhausted, PV+battery can support daytime loads indefinitely

The Cost of Resiliency

Grid-connected system saves $519,000 over project life, but provides 0 added resiliency

The microgrid system saves only $104,000 over the project life ($415,000 less), but provides an extra 1.8 days resilience plus indefinite daytime power

Is an extra 1.8 days resiliency worth $415,000?

Description	Grid-Connected	Microgrid
PV+Battery Installed Cost (before incentives)	$2,451,000	$2,451,000
Added Microgrid Cost	$0	$415,000
Total Installed Cost	$2,451,000	$2,866,000
Net Present Value	$519,000	$104,000
Added Resiliency (days)	0	1.8

Key Findings

At this site, integrating solar PV + battery with existing diesel generators provides $104,000 cost savings, 91% utility energy savings, and 1.8 days added resiliency

After diesel fuel supplies are exhausted, the site could continue to operate critical loads indefinitely during daytime hours when solar resource is sufficient using just PV+battery

Business interruption cost is not included in the economic analysis, but should be considered in the investment decision

Where Else Will this Work?

Utility rate tariff, incentives, technology costs, and solar resource drive solar PV + battery economic viability.

Sites with higher energy and demand rates (i.e California, New York, Hawaii)

Sites with good solar and storage incentives (i.e. California, New Jersey, Hawaii, Massachusetts)

Sites that place a high value on resiliency

Analysis Disclaimer

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The analysis is based on projections, estimates or assumptions made on a best-effort basis, based upon expectations of current and future conditions at the time they were developed. The analysis was prepared with information available at the time the analysis was conducted. Analysis results could be different if new information becomes available and is incorporated. This analysis is a starting point for additional research and consideration of investment options. Other factors that can inform decision-making are not considered here. The analysis results are not intended to be the sole basis of investment, policy, or regulatory decisions.

This analysis was conducted using the NREL REopt Model (http://reopt.nrel.gov). REopt is a techno-economic decision support model that identifies the cost-optimal set of energy technologies and dispatch strategy to meet site energy requirements at minimum lifecycle cost, based on physical characteristics of the site and assumptions about energy technology costs and electricity and fuel prices.

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THANK YOU!

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