Business & Technology Advisory

October 2023

Microgrid Planning Participation Opportunity for NRECA Members MGRAVENS

Opportunity Overview

NRECA and its partners at the National Labs have received federal research funding for a microgrid planning project and are looking to recruit cooperatives to participate.

We aim to work with coops who are interested in performing microgrid planning studies for new microgrids, either utility-owned or behind-the-meter. There is no cost to participate outside of some time required to gather data and guide the analysis.

The project activities that have been funded by the federal grant are:

1. Microgrid planning exercises executed by experts at the National Labs (Los Alamos National Lab (LANL), Sandia National Laboratories, National Renewable Energy Laboratory (NREL), and Lawrence Berkeley National Laboratory (LBNL)).
2. Detailed microgrid modeling and real-time, hardware-in-the-loop experiments at NREL.

If you are interested in participating or have any questions, please fill out this short form to indicate interest: https://forms.office.com/r/9vzSyWKAKR. To meet federal project deadlines, we will need to receive your response by **November 15th**, at which point we will be in touch about detailed steps to achieve the planning exercises.

Additional information about the project goals and technologies is included in the Appendix to this document.

Contact for Questions

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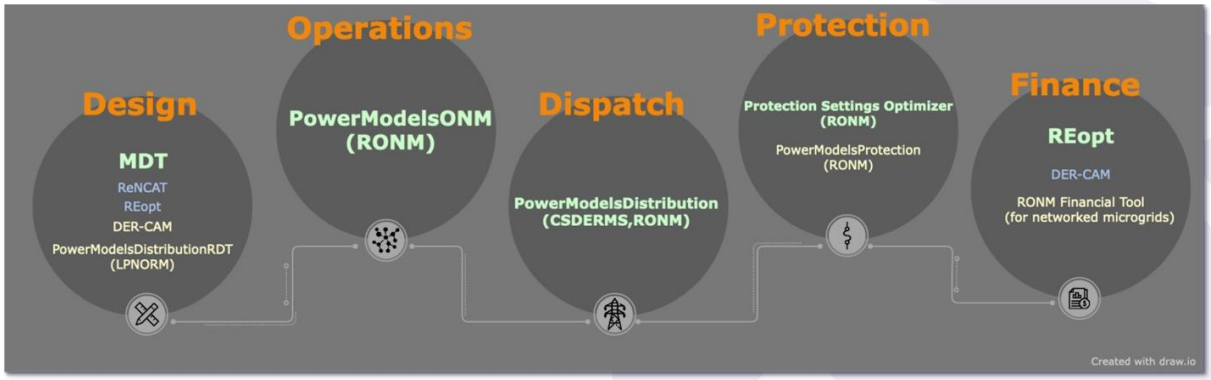
Appendix: Additional Information on MGRAVENS Project Goals and Technologies

MGRAVENS – Enabling End-to-End Microgrid Planning



- **Problem statement:** microgrid planning is a detailed and complex problem.
- **Project goal:** demonstrate planning capabilities across 5 domains (pictured above) and execute planning exercises with cooperatives leveraging expertise and tools at 4 DOE National Laboratories.

Los Alamos NATIONAL LABORATORY · NREL · Sandia National Laboratories · BERKELEY LAB · NRECA

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REopt: Optimal Microgrid Generation Planning

REopt helps partners make well-informed energy investment decisions backed by credible, objective data analysis by answering questions such as:

- How should DERs be sized to minimize site energy costs, achieve a renewable energy or emissions reduction target, and/or provide resilience value?
- How should I dispatch these technologies to maximize their value?
- What is the value (or net present value) of a project?

Alcatraz PV-battery-diesel hybrid system completed in 2012. NREL provided technical assistance to optimize the dispatch.

Ft. Carson 4.25 MW/8.5 MWh peak-shaving Li-ion BESS completed in 2019. NREL provided technical assistance to validate the $0.5 million/year savings.

Identified cost-effective renewable energy and microgrid projects to meet Time Warner Cable energy goals for reduced energy use, reduced energy cost, and increased resilience.

San Diego Gas & Electric and Sumitomo partnered with REopt team to develop daily dispatches for front-of-the-meter flow battery in SDG&E territory.

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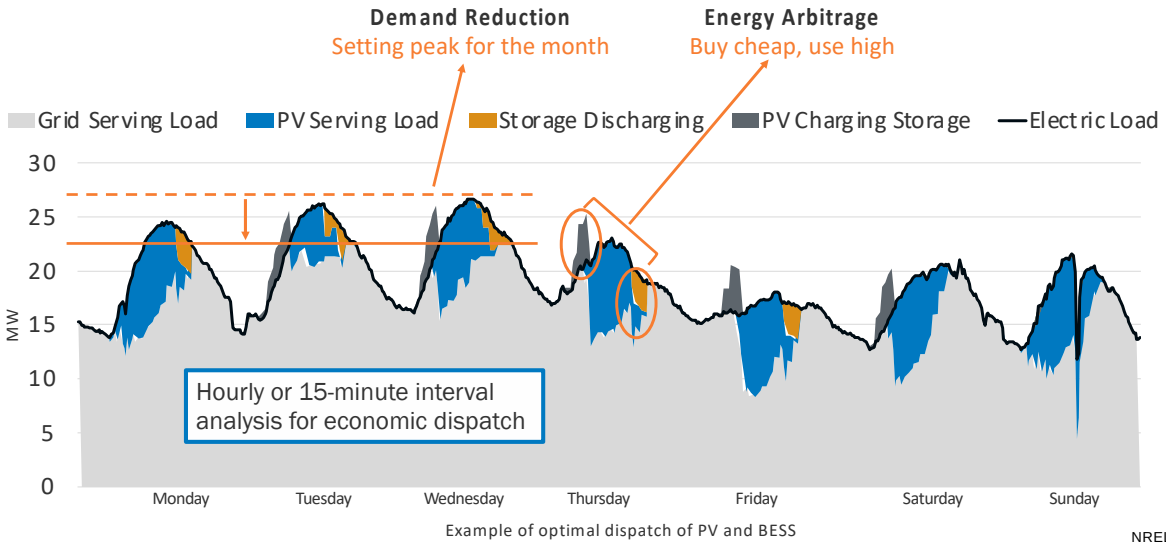
REopt: Grid-Connected Cost Savings

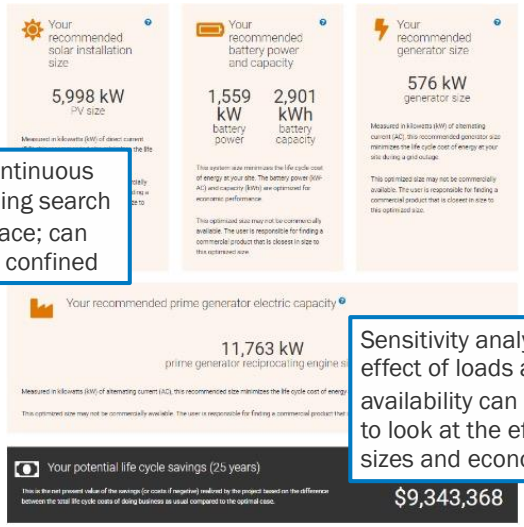
REopt considers the trade-off between ownership costs and savings across multiple value streams to recommend optimal size and dispatch.



Example of optimal dispatch of PV and BESS

REopt: Detailed Financial Estimates

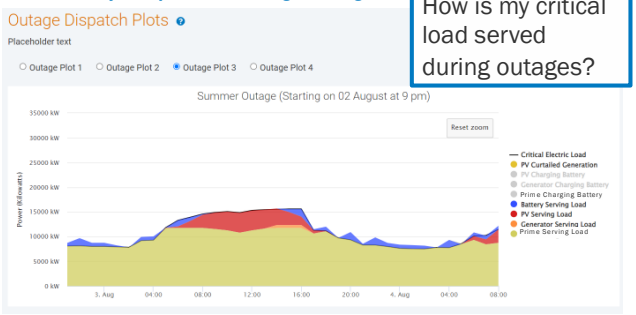
DER Sizes and Net Present Value



Continuous sizing search space; can be confined

Hourly Dispatch During Outages

How is my critical load served during outages?



What's my project IRR?

Key Financial Outputs

	Business As Usual	Resilience
Summary Financial Metrics		
Total Upfront Capital Cost Before Incentives	N/A	$30,669,448
Year 1 O&M Cost, Before Tax	$0	$987,162
Total Life Cycle Costs	$76,474,830	$67,131,462
Net Present Value	$0	$9,343,368
Payback Period	N/A	4.95 yrs
Internal Rate of Return	N/A	20.0%
PV Levelized Cost of Energy	N/A	$0.073/kWh

Sensitivity analysis on the effect of loads and resource availability can be performed to look at the effect on DER sizes and economics

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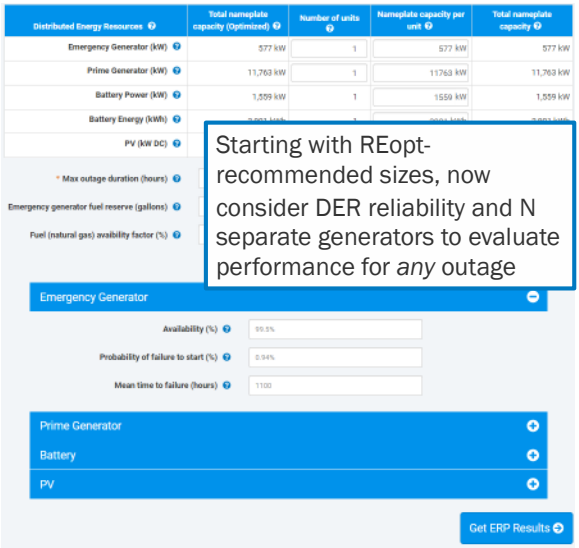
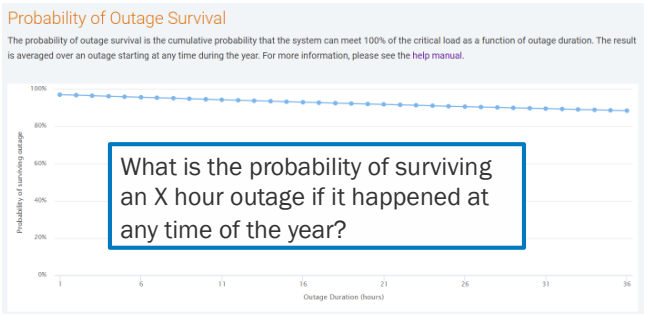
REopt's Energy Resilience Performance Simulation



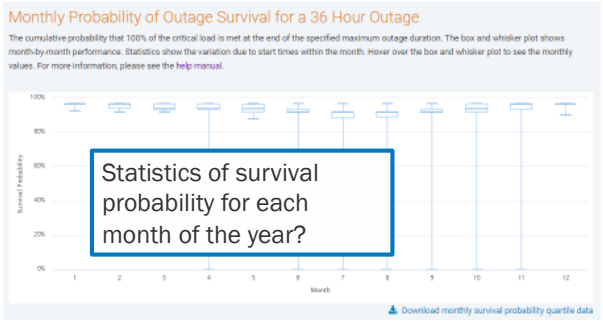
Starting with REopt-recommended sizes, now consider DER reliability and N separate generators to evaluate performance for *any* outage

DER sizes and reliability of DERs



What is the probability of surviving an X hour outage if it happened at any time of the year?

Probability of surviving ANY outage start time



Statistics of survival probability for each month of the year?

Monthly survival probability statistics

DER-CAM Planning Tool

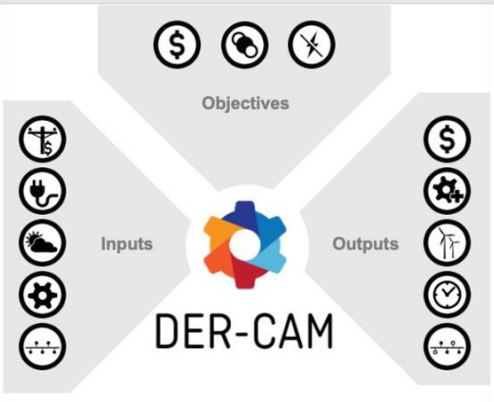
Background

DER-CAM is a well-established tool for DER/microgrid analysis. Recently deployed dercam-app.lbl.gov web platform hosts user-facing research and analysis tools including:

- DER-CAM Optimization API
- DER-CAM Web User-Interface
- Resilience Design Tool (new analysis application)

Impact

- DER-CAM has accrued a total user base of 3000+ users, and delivered solutions to 100,000+ design and analysis models.
- Increases access and relevance of existing tools to large potential user-base
- Reduces barriers to new project development



Technical Assistance to Communities

- DER-CAM model has been re-implemented to provide technical assistance for communities.
- Example: https://ouzinkieplanningtool.lbl.gov/

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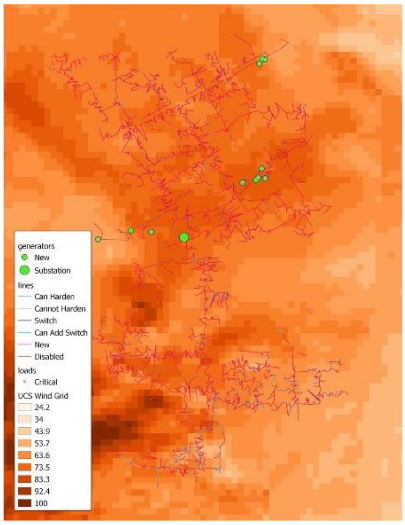
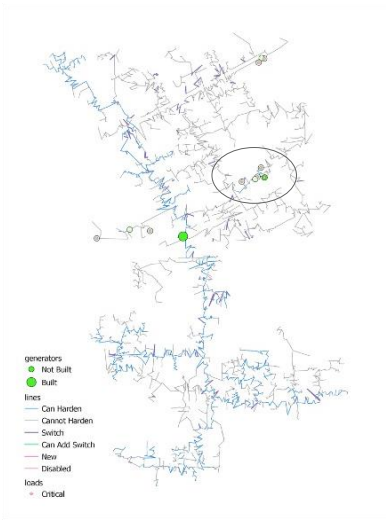
LPNORM – Calculating Hardening and Microgrid Options

- **LPNORM**
  - An open source distribution resilient design tool
  - Integrates damage prediction modeling, resilient design optimization, power flow modeling, and the Open Modeling Framework (OMF)
  - Collaboration between Los Alamos National Laboratory (LANL), Pacific Northwest National Laboratory (PNNL), The National Rural Electric Cooperative Association (NRECA), and Georgia Tech (GT)
- **Software Scope**
  - Recommend system designs to increase resilience to extreme events
    - Focused on estimating ability to meet critical and non-critical load immediately post event
  - Design options
    - Topology redundancy, configuration options, distributed generation
  - Hardening options
    - Vegetation trimming, undergrounded, guy wires, support poles
    - Modeled as reducing likelihood of damage during an extreme event

LNPORM Use Case — Extreme Wind Event





<u>Damage Profile</u>

- Extensive damage throughout the solution

<u>Requirements</u>

- Design to support all critical load in the model
- Design to support 50% of non-critical load

<u>Solution Highlights</u>

- Design solution creates hardened backbones to serve a sufficient amount of non-critical load.
- Northeastern network is allowed to fail–critical load served by a local microgrid

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PowerModelsONM – Microgrid Resilience Analysis

- Distribution feeder **restoration planning**, **system hardening**, and **optimal dispatch**
  - High-fidelity physics and engineering constraints
- Explore the effects of different restoration strategies
  - Apply multiple contingencies
  - Change limits and constraints
- Develop system partitions to harden against extreme events in the face of uncertainty
- Perform financial analysis to judge the economics of microgrid installation

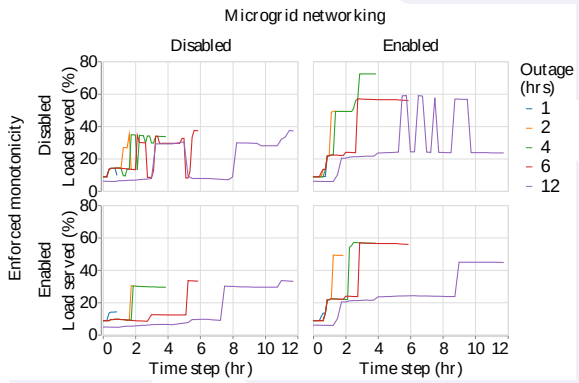

Table 1: Utility outage cost comparison between networking enabled and disabled, for three different maximum switch closure actions per time step, for outages of length 1, 2, 4, 6, or 12 hours.

Outage Duration	Networking Enabled				Networking Disabled				Average Cost Difference
	1 Switch Action	2 Switch Actions	3 Switch Actions	Avg.	1 Switch Action	2 Switch Actions	3 Switch Actions	Avg.	
1 hour	$337k	$306k	$299k	$315k	$336k	$328k	$335k	$333k	$18k
2 hours	$476k	$413k	$396k	$428k	$534k	$528k	$528k	$530k	$102k
4 hours	$730k	$702k	$704k	$712k	$935k	$935k	$940k	$936k	$224k
6 hours	$1,143k	$1,140k	$1,156k	$1,149k	$1,429k	$1,428k	$1,422k	$1,427k	$278k
12 hours	$1,866k	$1,848k	$1,822k	$1,846k	$2,009k	$2,009k	$2,009k	$2,008k	$162k

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PowerModelsONM – Microgrid Resilience Analysis

Restoration sequences validated with **Hardware-in-the-Loop** (HIL), providing assurance of the physical accuracy of the restoration strategies

- Operational stability verified and operations ensured to not result in abnormal harmonics or infeasible mode changes (i.e., grid-forming/grid-following)

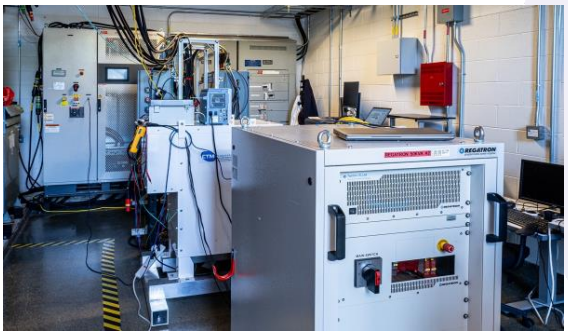
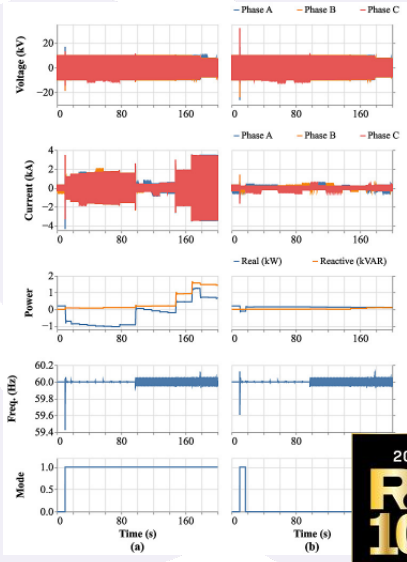


Photo by NREL. NREL-owned ABB FC inverter



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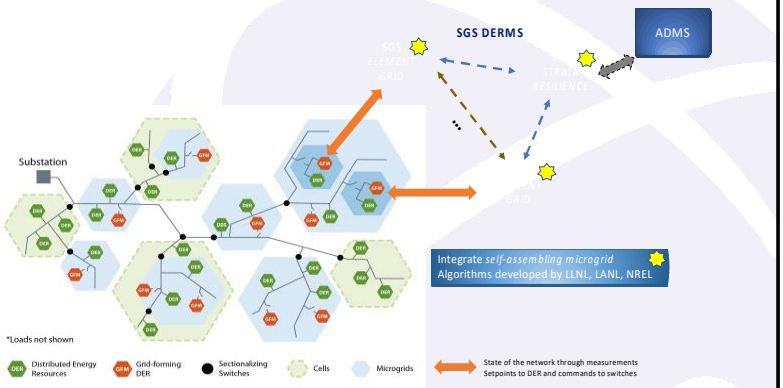
PowerModelsONM – Microgrid Resilience Analysis

- Being *deployed* on Smarter Grid Solutions' commercial **Strata Resilience** DERMS platform
  - DOE Technology Commercialization Fund Project
- Resilience and financial analysis performed for **Cobb EMC** & **San Diego Gas & Electric**
  - DOE Office of Electricity Project



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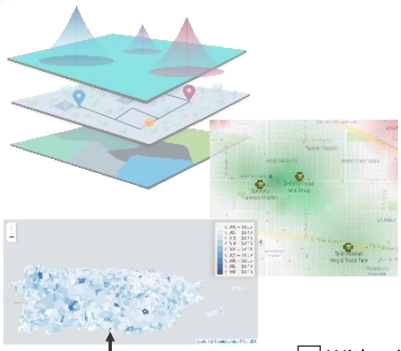
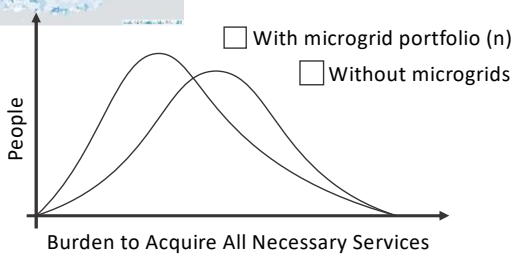
ReNCAT - A Need to Act on the Social Burden Metric to Make Optimal and Equitable Power Infrastructure Decisions





Want to make sure that people within communities have critical needs met during emergency situations?

Knowing that burden exists still doesn't tell us how we can best minimize its impact on people using limited resources and constrained by legacy infrastructure investments!

Need a tool to help with:

- Siting infrastructure investments
- Evaluating alternative projects
- Understanding public safety power shutoff plan (PSPS) impacts
- Mitigation measures

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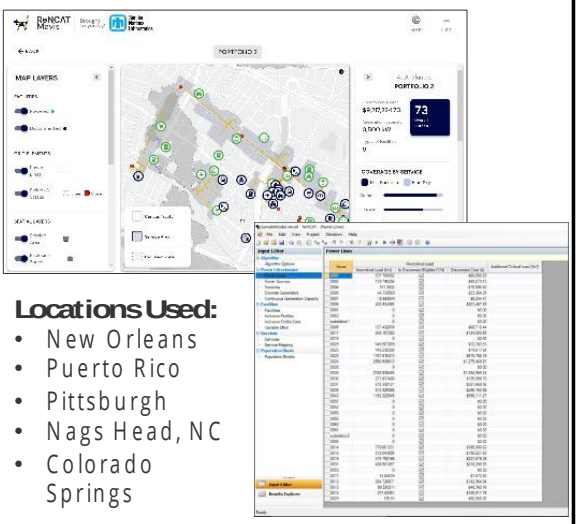
What is ReNCAT?

ReNCAT stands for the Resilient Node Cluster Analysis Tool created by Sandia National Laboratories

- Desktop application
  - Active development since 2016
- Optimization tool
  - Uses genetic algorithm to site and size resilience solutions across a broad landscape
- Grid and other critical infrastructure explicitly modeled
  - Uses distribution system layout and identifies which sub feeders to energize based on critical infrastructure locations and services
- Identifies portfolios of resilience solutions that optimize for social burden vs cost
  - Calculated burden to residents to obtain critical services
  - Balances against cost of generation needed to power microgrids
- Can also be used for social burden evaluation



Locations Used:

- New Orleans
- Puerto Rico
- Pittsburgh
- Nags Head, NC
- Colorado Springs

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Funded by:

ProtSetOpt – Problem Statement

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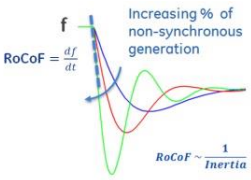
- The grid is getting more complicated, with increasing number of possible states
- The conventional protection system lacks the intelligence required to modify the protective responses according to the system conditions

Current Protection Schemes

Local Fault Detection

- Well-tuned only for normal operating conditions
- Does not work with distributed energy resources (DER) with reverse current or inverter-based generation with low fault currents



Logic-Based Adaptive Protection

- Reliant on communication, which also introduces cyber-security vulnerabilities
- Based on a set of pre-defined logics
- Covering a limited number of contingencies

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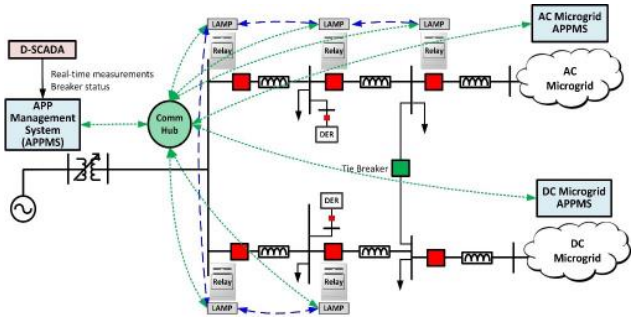
ProtSetOpt - Adaptive Protection Platform

Funded by: Sandia National Laboratories, SOLAR ENERGY TECHNOLOGIES OFFICE, U.S. Department of Energy

- Adaptive Protection Platform (APP) to be utilized in modern distribution systems with high penetration of PV as well as AC and DC microgrids.

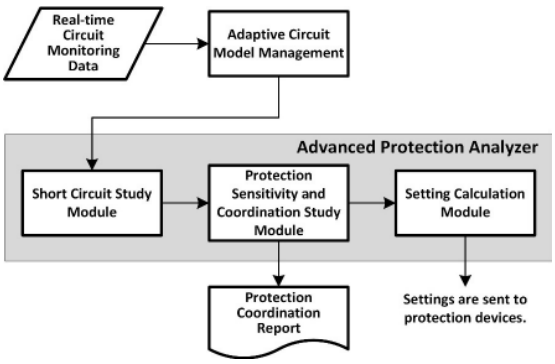


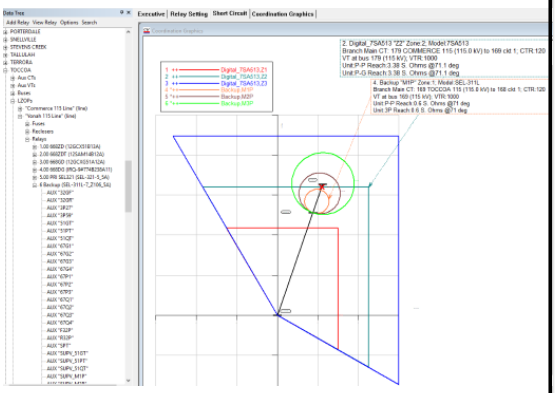
- Determine appropriate relay settings in real-time for all devices in the network based on the current system state (switching, grid-connected, generator dispatch, etc.)

ProtSetOpt - Adaptive Protection Platform

Funded by: Sandia National Laboratories, SOLAR ENERGY TECHNOLOGIES OFFICE, U.S. Department of Energy

- APP Management System (APPMS)
  - Model-based algorithms in Adaptive Circuit Model Management
  - Uses CAPE for model-based Short Circuit Study Module, and wide-area Sensitivity and Coordination Study Module
  - Derive optimized and coordinated relay settings





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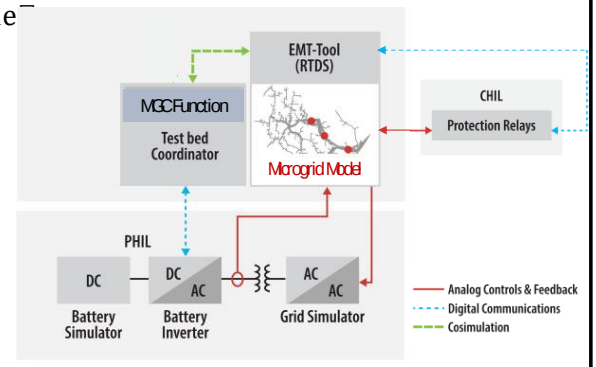
NREL will perform laboratory evaluation of the microgrid designs for MGRAVENS

- Demonstrate feasibility of design(s) developed for the RAVENS use cases through
- Real-time, hard-in-the-loop (HIL) simulations
  - Electromagnetic transient (EMT) simulations
  - Multiple simulated DERs and key hardware DER
  - Evaluate stability in islanded operation
  - Captures transients from island/reconnection
  - Can introduce faults and evaluate protection designs (simulated and HIL relays)
  - Use basic microgrid controller (MGC) function developed by NREL
- Outputs:
  - EMT model of microgrid in RSCAD format
  - Simulation results



Photos by NREL

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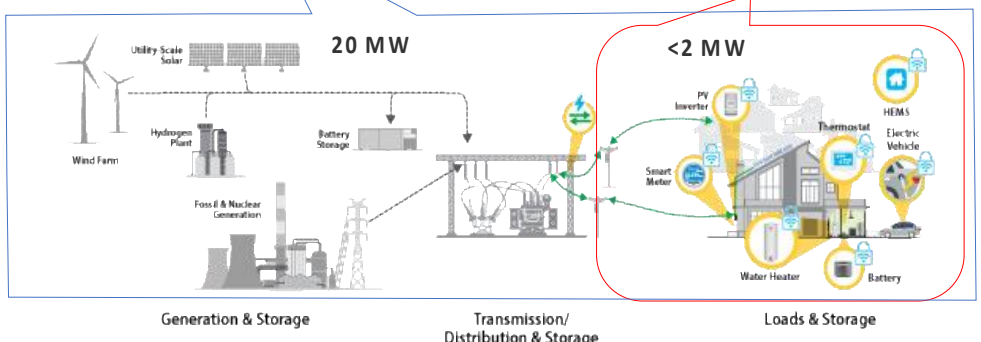
NREL's ARIES Research Platform at Scale



ARIES is a **globally unique research capability** that can be used to demonstrate that distributed energy resources (DERs) can operate in real-time energy markets and provide reliable and resilient grid services.

Photos by NREL

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