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Enhancing Microgrid Deployment Across the States

A NARUC-NASEO Roundtable

NASEO

National Association of State Energy Officials

NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS

DEDICATED TO PUBLIC SERVICE

1889

February 12 – 13, 2020

Facilitated by NARUC and NASEO with support from the U.S. Department of Energy, Office of Electricity

Agenda (Day 2)

- 8:30 – 9:00 Welcome, Check-In, and Presentation from DOE OE
- 9:00 – 11:15 Federal Tools and Resources Presentations from Sandia, NREL, EPA, and LBNL
  - 9:00 – 9:30 Will McNamara, Sandia National Labs
  - 9:30 – 10:00 Dan Olis, National Renewable Energy Lab
  - 10:15 – 10:45 Neeharika Naik-Dhungel, Michelle Madeley, Abby Hall, EPA
  - 10:45 – 11:15 Nicholas DeForest, Lawrence Berkeley National Lab
- 11:15 – 11:30 Wrap-Up, Takeaways, Conclude

Urban Resilience Planning Process

Sandia National Laboratories

NASEO
National Association of State Energy Officials

NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS
DEDICATED TO PUBLIC SERVICE
1889

Will McNamara, SNL

Background

- To address the economic valuation of resilience-focused grid investments, the US Department of Energy (US DOE) funded a team of researchers from Sandia National Laboratories (Sandia) and Los Alamos National Laboratory (Los Alamos) to develop and apply an approach for identifying and prioritizing grid investments targeted at improving community resilience.

- This project, funded through US DOE's Grid Modernization Laboratory Consortium (GMLC), is the first of its kind to collaboratively address grid investments aimed at minimizing extreme consequences to the community.

Background

- Sandia defines resilience as follows:
- *"Resilience is defined as the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. [This] includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents."*
- Based on this definition, Sandia and colleagues have developed a mathematical framework to calculate, project, and improve resilience.

+ Overview of Framework

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- Based on this definition, Sandia and colleagues have developed a mathematical framework to calculate, project, and improve resilience.

Overview of Framework

- Guiding questions that the framework and accompanying modeling tool seek to address and model for specific communities:
- What are the characteristics of extreme events that would result in worst consequence to the community? How is that consequence measured?
- In the case of these events, how does the grid perform? What other infrastructure services will be impacted due to loss of power? What is the consequence of these service outages?
- What grid modernization options will minimize this consequence, thereby best improving community resilience? How would these options be designed to work within the current grid?
- What are the scale and cost of grid improvements needed to improve community resilience? How would resilience metrics be best defined and utilized for future community planning and adaption to future resilience challenges and needs?

Overview of Framework

- This framework relies on estimating the performance of systems of interest during extreme events and translating this performance into **METRICS OF CONSEQUENCE** that are most useful to stakeholders' existing planning paradigms.
- The approach supports the analysis of consequence for community resilience metrics and/or the evaluation of resilience-enhancing solutions.

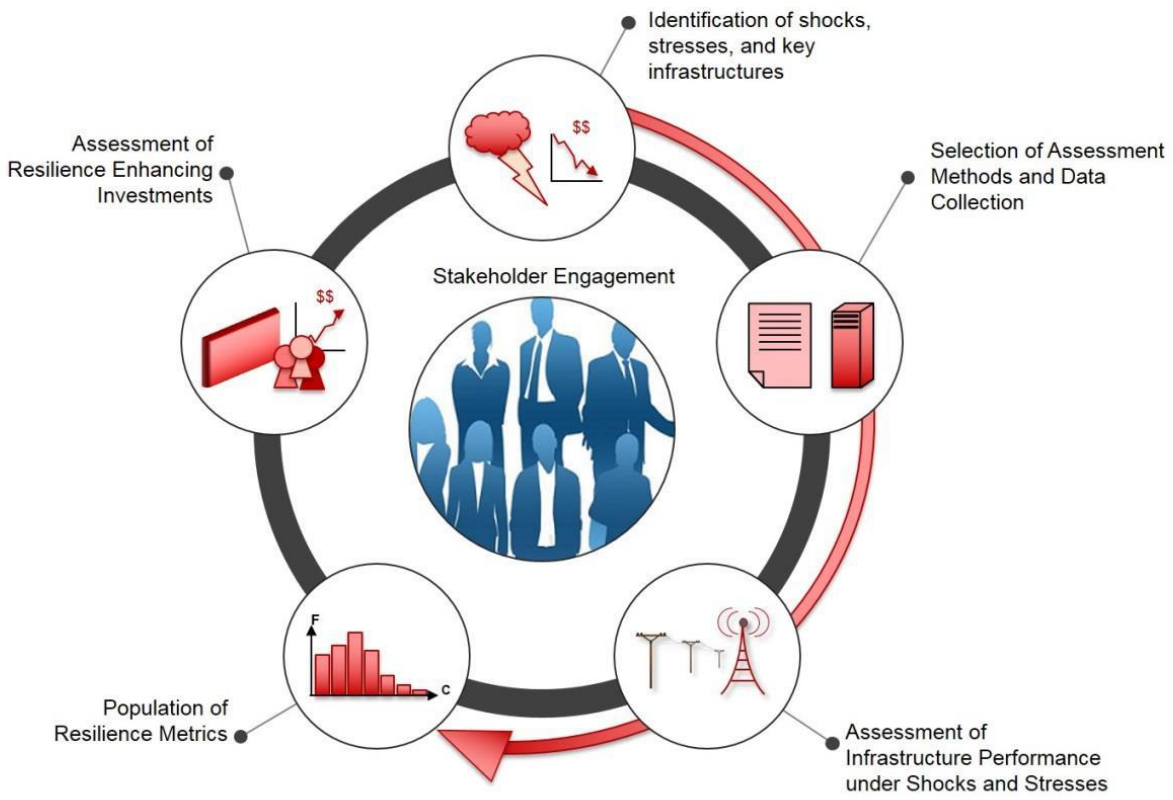
Overview of Framework

- There are two primary classifications of **METRICS OF CONSEQUENCE** that are included in the modeling:

Community Measures	• Number of People without Necessary Services • Live at Risk • Net Population Change
Economic Measures	• Gross Municipal Product Loss • Change in Capital Wealth • Business Interruption Costs

Five Stages of the Urban Resilience Planning Process

- The **FIVE STAGES** of the urban resilience planning process are outlined in the following chart.
- The process begins at the top of the diagram and continues in a clockwise fashion iteratively until sufficient resilience-enhancing investment suggestions have been provided.



Five Stages of the Urban Resilience Planning Process

- **#1—IDENTIFICATION OF THREATS** and infrastructures of concern
- Hurricanes
- Tornadoes
- Earthquakes
- Anything that will result in extended power outages

Five Stages of the Urban Resilience Planning Process

- **#2—IDENTIFICATION OF DATA AND TOOLS** already in use for infrastructure resilience planning
- Tools and data are augmented with tools and data developed at Sandia and Los Alamos with support from the US DOE and US Department of Homeland Security.

Five Stages of the Urban Resilience Planning Process

- **#3—ASSESSING THE PERFORMANCE OF INSTRASTRUCTURES** of concern subject to the threats of concern. Performance can be described by:
- Outage frequency
- Number of customers impacted
- Outage duration
- Or a combination of these, such as customers impacted multiplied by duration

Five Stages of the Urban Resilience Planning Process

- **#4**—**MAPPING GRID RESILIENCE TO INFRASTRUCTURE SERVICES**, including identification of those infrastructure services that have low baseline resilience are those with no backup power. Infrastructure services include:
- 911 system
- Emergency services (police, fire)
- Shelters (city-assisted, hotels)
- Medical services (hospitals, air ambulance)
- Provisions (pharmacies, gas stations, groceries, banks)
- Water and Wastewater (water purification, sewage treatment)

Five Stages of the Urban Resilience Planning Process

- **#5—SPECIFYING INFRASTRUCTURE IMPROVEMENTS** that improve the community resilience metric.
- Improvements are grid modernization technologies that take into account both the infrastructure services needed (at a granular, zonal level) and the cost of added resilience.
- At the end of this process, stakeholders gain measurable resilience metrics useful in their existing planning processes and an analysis of how potential resilience-enhancing solutions will improve these metrics.

Practical Use Cases

- To apply this resilience framework to communities, Sandia has worked with cities to propose measurement units for resilience metrics that work within current planning paradigms and adequately convey the goals and benefits of resilience-enhancing investments.
- City of Norfolk, VA
- Puerto Rico
- City of New Orleans, LA

+ Practical Use Cases: New Orleans

- **STEP #1 (IDENTIFICATION OF THREATS)**
  - Hurricanes and severe storms accompanied by large rainfall totals are the threat of highest concern.
  - A reasonable worst consequence storm is a Category 2 or low Category 3 hurricane in which the city does not issue a mandatory evacuation, and the storm stalls over New Orleans, dropping 20 to 25 inches of rain over a period of 24 hours.
  - In this case, the New Orleans partners indicated that many people would be displaced and in need of infrastructure services. This represents the "design basis threat" for selection of potential grid resilience improvements.
- **STEP #2 (TOOLS AND DATA)**
  - Sandia augmented the tools and data that the City of New Orleans had in place with tools and data from Sandia, Los Alamos and DOE

+ Practical Use Cases: New Orleans

- **STEP #3 (ASSESSING PERFORMANCE OF INFRASTRUCTURES)** involved analysis of three factors:
  - Wind and inundation impacts of the design basis threat
  - Power system performance subject to the design basis threat
  - Infrastructure services subject to the design basis threat and the power system performance
    - Analysis showed that infrastructures served by overhead distribution lines in vegetated areas were at highest risk of extended outage due to extreme storms, followed by infrastructures served by overhead lines and less vegetation, areas with underground service and high potential for flooding.

- **STEP #4: (MAPPING GRID RESILIENCE TO INFRASTRUCTURE SERVICES)**
  - The resilience metric chosen for this study—the percentage of infrastructures with sufficient backup power—focuses on lifeline infrastructure services and the ability to support critical needs of the community.

Practical Use Cases: New Orleans

- **Step #5 (SPECIFYING INFRASTRUCTURE IMPROVEMENTS)**
  - **Advanced Microgrids:** Advanced microgrids utilize automated controls to tie together a collection of facilities within a relatively small geographical area using one or more points of common coupling (PCCs) to the utility. These PCCs are switching devices that can automatically segregate the microgrid from the distribution system in an outage situation.
  - **Distribution System Flexibility and Automation:** Grid modernization options, such as automated reclosers and automated fault location, isolation, and system recovery (FLISR) software, can provide the grid operator with much faster control over distribution switching and reconfiguration, thereby greatly decreasing outage durations especially for smaller disruptions.
  - **Localized Backup Generation:** Building-tied backup generators are the most common method of supplying power to a facility to enable operation of critical functions during utility outages.

Practical Use Cases: New Orleans

- In the near-term, prioritization of resilience nodes will be accomplished via further research and demonstration by the Department of Energy's Grid Modernization Laboratory Consortium with New Orleans partners.
- In the long-term, populating the community-focused resilience metric suggested for New Orleans requires overcoming significant science and technology gaps (e.g., projection of future threats, projection of future population needs).
- This summary represents the Phase 1 work done for the City of New Orleans. There has also been a Phase 2 that was completed in early 2019 that developed more detailed designs and co-optimized microgrid designs to balance the value for blue sky (value during normal days) and black sky (value during disruptions or outages).

Contact

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- Will McNamara, SNL, 505-206-7156, jwmcnam@sandia.gov

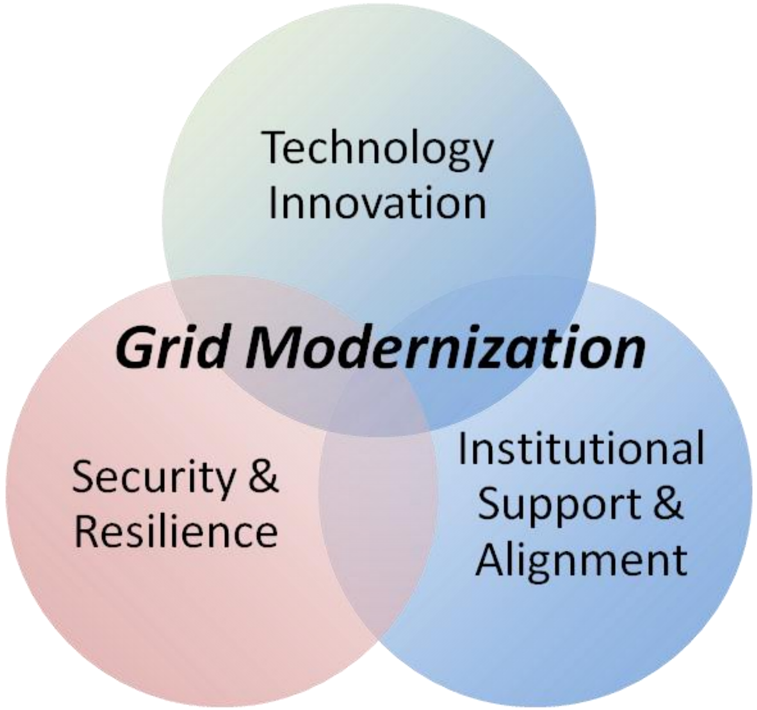
U.S. DEPARTMENT OF
ENERGY
Office of Electricity

NARUC-NASEO
Microgrid State Working Group Roundtable
February 2020

Dan Ton
DOE – Office of Electricity

DOE Microgrid R&D Program

- A program within the DOE Office of Electricity (OE) Advanced Grid Research department
- R&D on microgrids to:
  - Enhance the resilience of the Nation's critical infrastructure,
  - Contribute to grid reliability, restoration and recovery, and
  - Improve the efficiency and flexibility of the electric sector
- Support of OE's thrust in electric grid modernization and resiliency in the energy infrastructure



Program Development and Application Space

TYPES OF MICROGRIDS

- ✓ Remote/island
- ✓ Grid-Connected: Singular and multiple networked
- ✓ AC, DC, hybrid
- ✓ Scale: kW to 10s of MW

MARKET SEGMENTS & OWNERSHIP

- ✓ Defense and civilian critical infrastructure
- ✓ Industrial, commercial, community, feeder
- ✓ Customer and utility owned

Partnership in Development and Deployment of Microgrid Technologies and Systems

National Labs

- Foundational R&D
- Models, tools, and integrated toolsets for planning/design and operations/control

Private Sector

- Commercial adoption
- Industry advisory
- Demonstration and implementation

States

- Technical assistance in technology deployment and adoption
- NARUC-NASEO Microgrid State Working Group

Program Partnership Activities with States

- Technical Assistance in Technology Deployment
  - Adoption, and training in use, of microgrid technologies, tools, and methods
  - Energy master planning to include microgrids + resiliency
  - Microgrid studies for technical and economic feasibility
- Independent Technical resources
  - Input to microgrid grant solicitations
  - Review of microgrid proposals
  - Assessment of microgrid projects
- Joint Solicitations and Awards
  - Co-funding of projects that meet mutual interest
- Any other collaborative opportunities proposed by States to accelerate broad deployment of microgrids

Suite of Tools Applicable for Energy Master Planning and Microgrid Feasibility Analysis

REopt Lite
SMPL-NZP Tool™
DER-CAM+
HOMER Pro

"Blue Sky" Analysis

- Minimum CapEx + OpEx
- Maximum ROI

"Black Sky" Analysis

Threat-inclusive:
- Targeted Energy Availability
- Minimum Impact to Mission Assurance

Microgrid Design Toolkit

Simulation

GridLAB-D
CYME International T&D

- Is the design operationally feasible under islanded and grid-tied scenarios?

Threat-agnostic:
- Minimum hours out per year
- Minimum VoLL loss

DER-CAM+
MIT Lincoln Laboratory
Los Alamos National Laboratory

Thermal + Electrical

No single tool truly co-optimizes the microgrid design for **resilience + efficiency + sustainability** AND ensures the design is physically feasible/realistic

Three Exemplar Tools To be Presented

REopt Lite

SMPL-NZP Tool™

DER-CAM+

HOMER Pro

"Blue Sky" Analysis

- Minimum CapEx + OpEx
- Maximum ROI

Simulation

GridLAB-D

CYME International T&D

- Is the design operationally feasible under islanded and grid-tied scenarios?

"Black Sky" Analysis

Threat-inclusive:
- Targeted Energy Availability
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Microgrid Design Toolkit

Threat-agnostic:
- Minimum hours out per year
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DER-CAM+

MIT Lincoln Laboratory

Los Alamos National Laboratory

Thermal + Electrical

No single tool truly co-optimizes the microgrid design for **resilience + efficiency + sustainability** AND ensures the design is physically feasible/realistic

Broad Partnerships

Argonne National Laboratory
Pacific Northwest National Laboratory
Oak Ridge National Laboratory
Sandia National Laboratories
Berkeley Lab
NREL Transforming ENERGY
Los Alamos National Laboratory
Brookhaven National Laboratory

Duke Energy
Southern Company
ComEd An Exelon Company | powering lives
PECO An Exelon Company
CenterPoint Energy
epb
Seattle City Light

Dominion Energy
Entergy
DLC Duquesne Light Co.
Avista
MISO
WECC
NERC North American Electric Reliability Corporation
ISO new england 20 years

EPRI Electric Power Research Institute
TDX power a tanadgusix company
GE
GE Global Research
Schneider Electric
SEL Schweitzer Engineering Laboratories
Burns Engineering

Alaska Energy Authority
AVEC Alaska Village Electric Cooperative
New York State of Opportunity. Reforming the Energy Vision
California Energy Commission
BPU New Jersey Board of Public Utilities
Power Secure
Microgrid Institute

Washington State University
UCI University of California, Irvine
The University of Tennessee Knoxville
ACEP Alaska Center for Energy and Power
University of Pittsburgh

NARUC National Association of Regulatory Utility Commissioners
NASEO National Association of State Energy Officials

Questions?

Introductions

- Your name, title, and organization

Federal Tools and Resources for State Microgrid Deployment

Sandia National Laboratory

Short Break

Assessing Customer Distributed Energy Systems using NREL's REopt Lite Tool

Dan Olis, Senior Engineer, National Renewable Energy Laboratory

NARUC-NASEO Microgrid Roundtable

February 13, 2020

NREL at a Glance

2,050

Employees,
plus more than
400
early-career researchers and visiting scientists

World-class
facilities, renowned technology experts

nearly 820

Partnerships
with industry, academia, and government

Campus
operates as a living laboratory

Will DER Work for Your Site?

Solar & Wind Resource

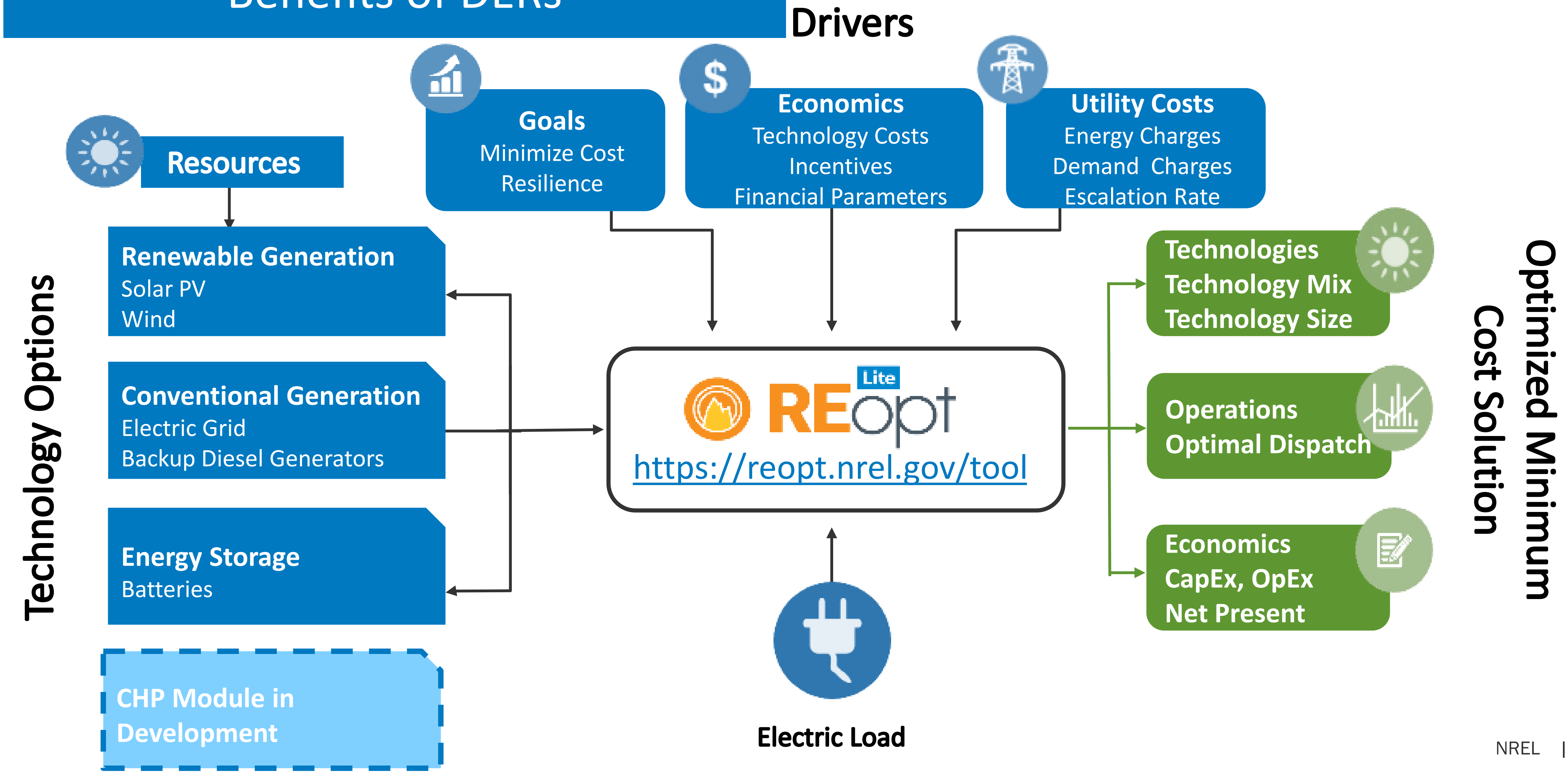
Technology Costs & Incentives

Space Available

Utility Cost & Consumption

Financial Parameters

REopt Lite: Free Web Tool to Optimize Economic & Resilience Benefits of DERs



Who’s Using REopt Lite?

Researchers

How will RE deployment change in the future?

Developers

Where are the best market opportunities?

Home and Building Owners

What technologies are best for my site?

Utilities

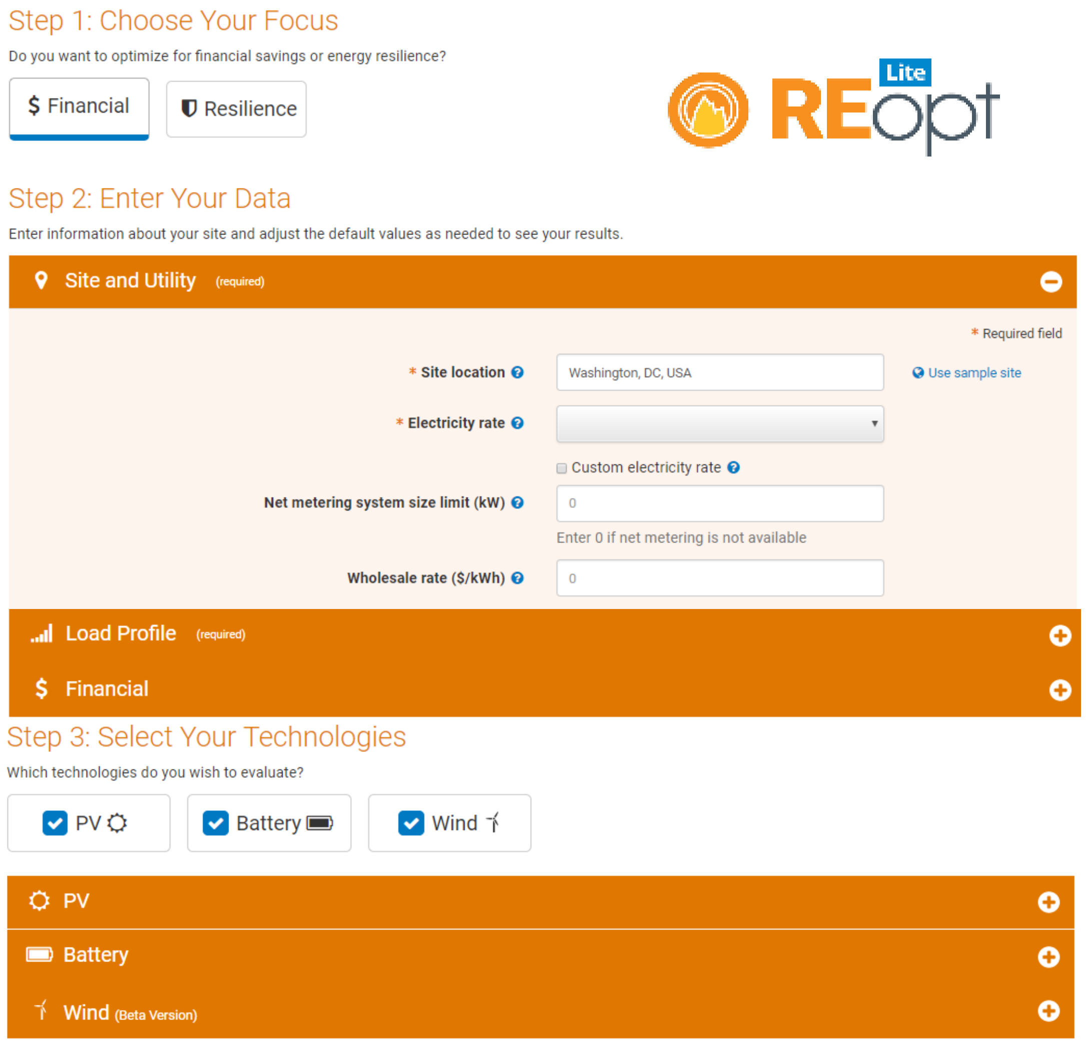
What value do these systems provide?

Government

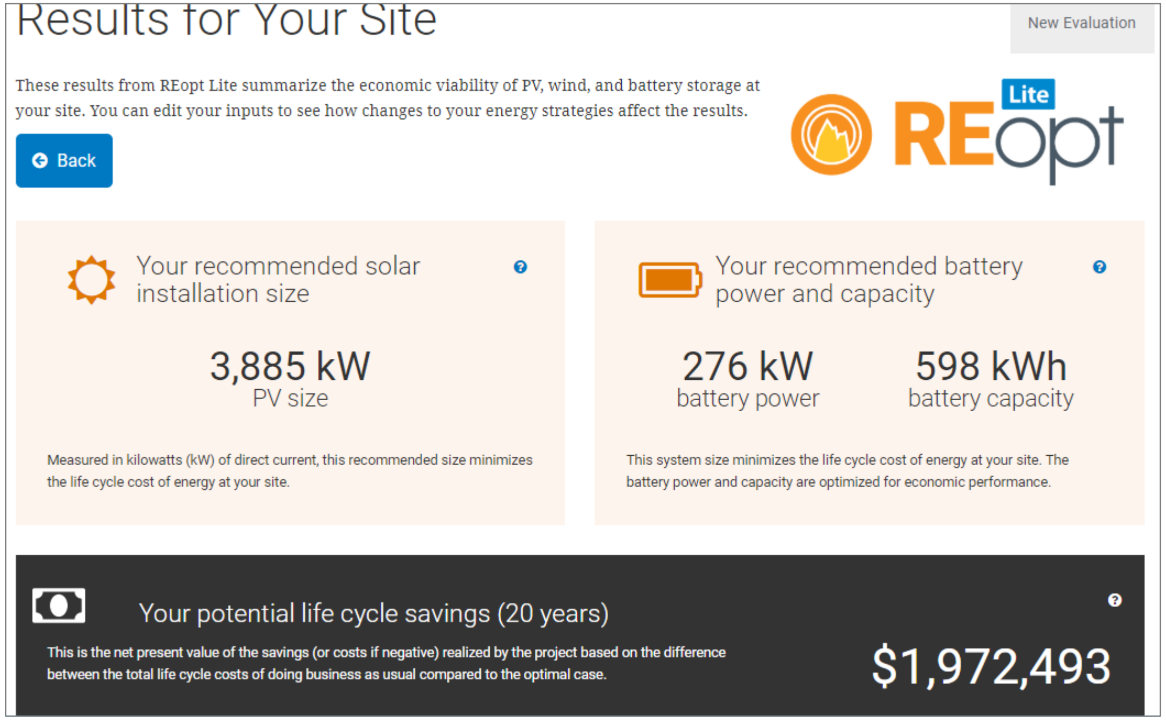
What policies might support DER deployment?

REopt Lite Web Tool

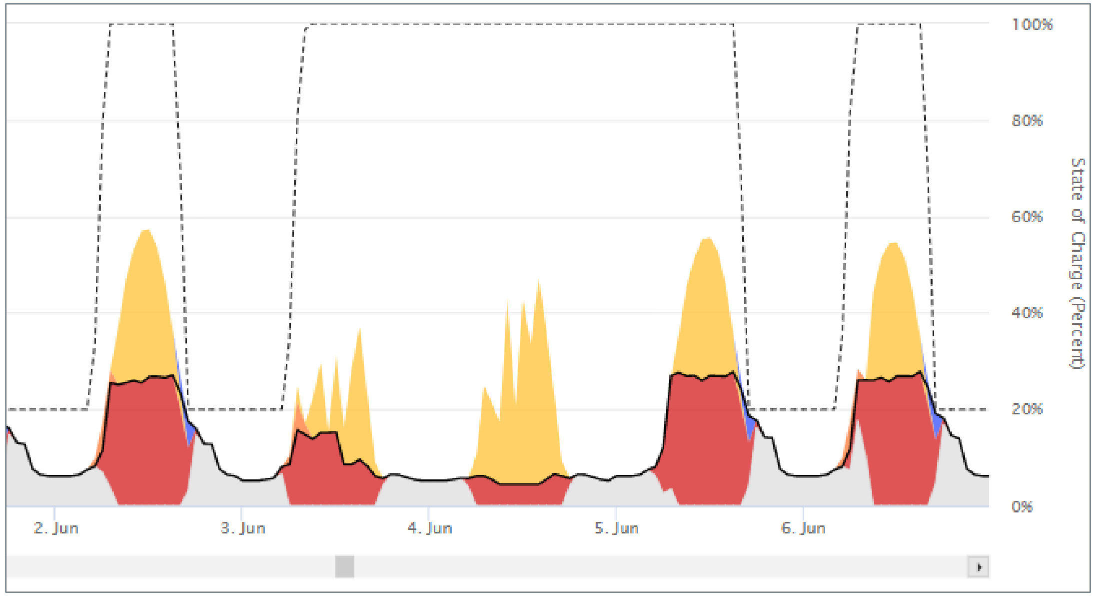
- **REopt Lite** is a web tool that offers a no-cost subset of NREL's more comprehensive REopt model
- **Financial mode** optimizes PV, wind, and battery system sizes and battery dispatch strategy to minimize life cycle cost of energy
- **Resilience mode** optimizes PV, wind, and battery systems, along with back-up generators, to sustain critical load during grid outages and to minimize life cycle cost of energy
- To access REopt Lite: https://reopt.nrel.gov/tool



REopt Lite Key Outputs



System Size and Net Present Value



Hourly Dispatch

	Business As Usual	Financial	Difference
System Size, Energy Production, and System Cost			
PV Size	0 kW	113 kW	113 kW
Annualized PV Energy Production	0 kWh	132,000 kWh	132,000 kWh
Battery Power	0 kW	0 kW	0 kW
Battery Capacity	0 kWh	0 kWh	0 kWh
Net CAPEX + Replacement + O&M	$0	$133,318	$133,318
Energy Supplied From Grid in Year 1	132,000 kWh	65,384 kWh	66,616 kWh
Year 1 Utility Cost — Before Tax			
Utility Energy Cost	$18,112	-$404	$18,515
Utility Demand Cost	$0	$0	$0
Utility Fixed Cost	$0	$0	$0
Utility Minimum Cost Adder	$0	$0	$0

Detailed Financial Outputs

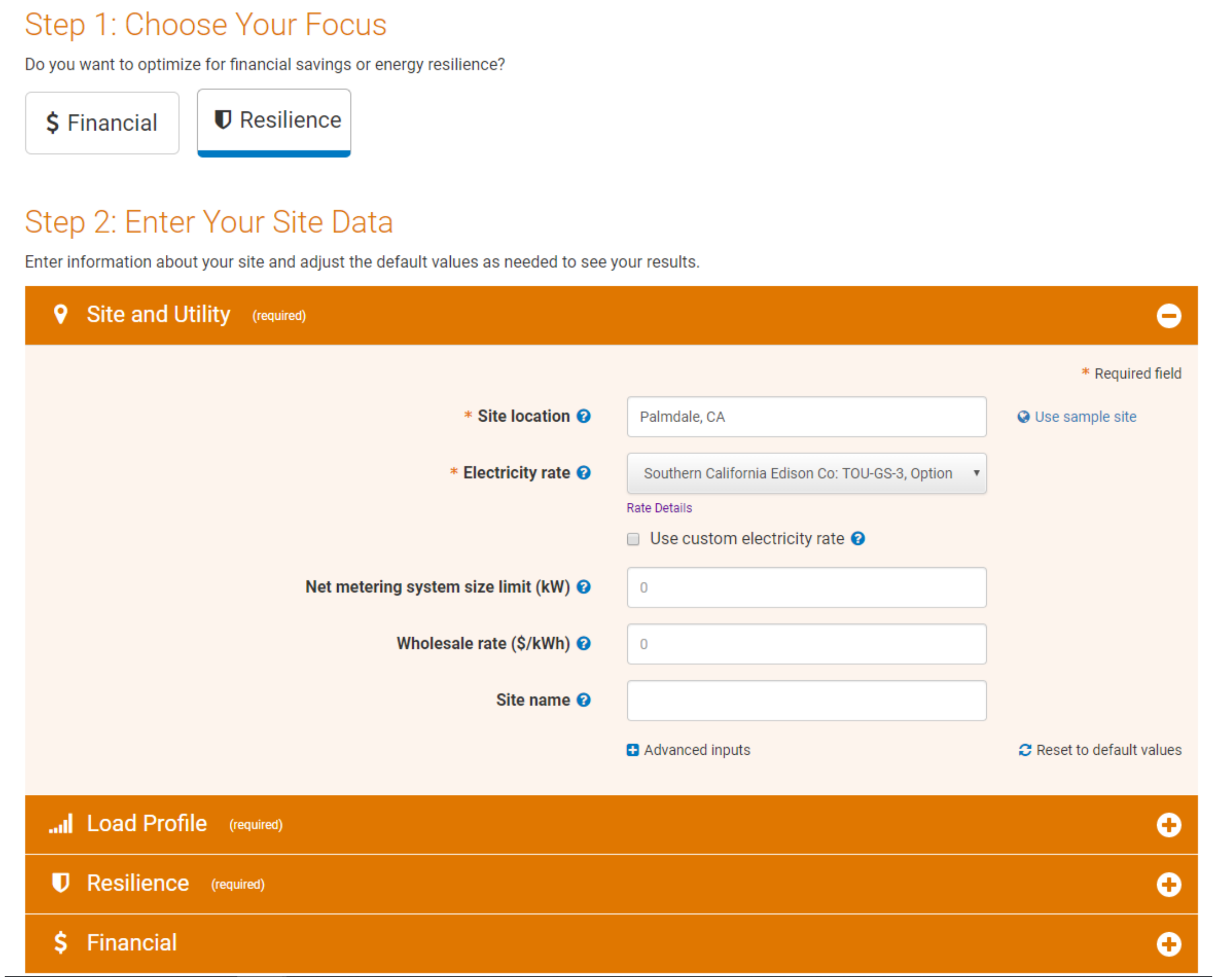
Recent Resilience Update

- **October 2019:** Resilience Modeling, Diesel Generator Sizing, Load Profile Dashboard, Utility Rate Help, International Guidelines, and Updated Cost Assumptions

- **February 2020:** Release of Open Source version of REopt Lite
- **April 2019:** PVWatts and Solar Resource Data Set Upgrade
- **March 2019:** Custom Hourly Rate Tariffs and Integrated Critical Load Builder
- **November 2018:** Wind Module, Custom Monthly Rate Tariffs, Critical Load Builder, and User Dashboard
- **June 2018:** Enhanced Resilience Features
- **March 2018:** Application Programming Interface
- **September 2017:** REopt Lite's Initial Release

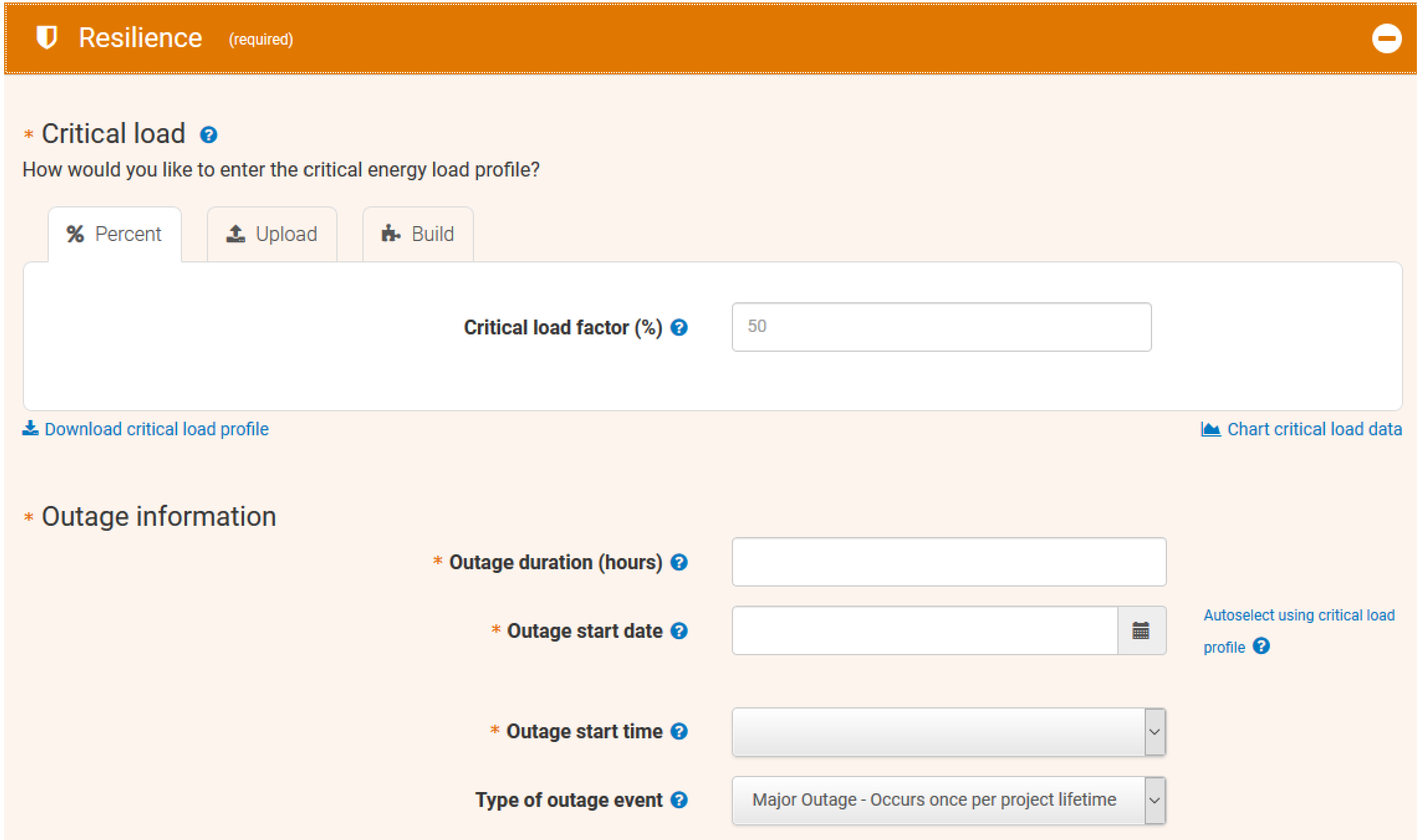
REopt update history: https://reopt.nrel.gov/software-update-history.html

Resilience in REopt



Resilience analysis uses the same general formulation as 'Financial' analysis but includes periods of grid outages

Resilience Inputs

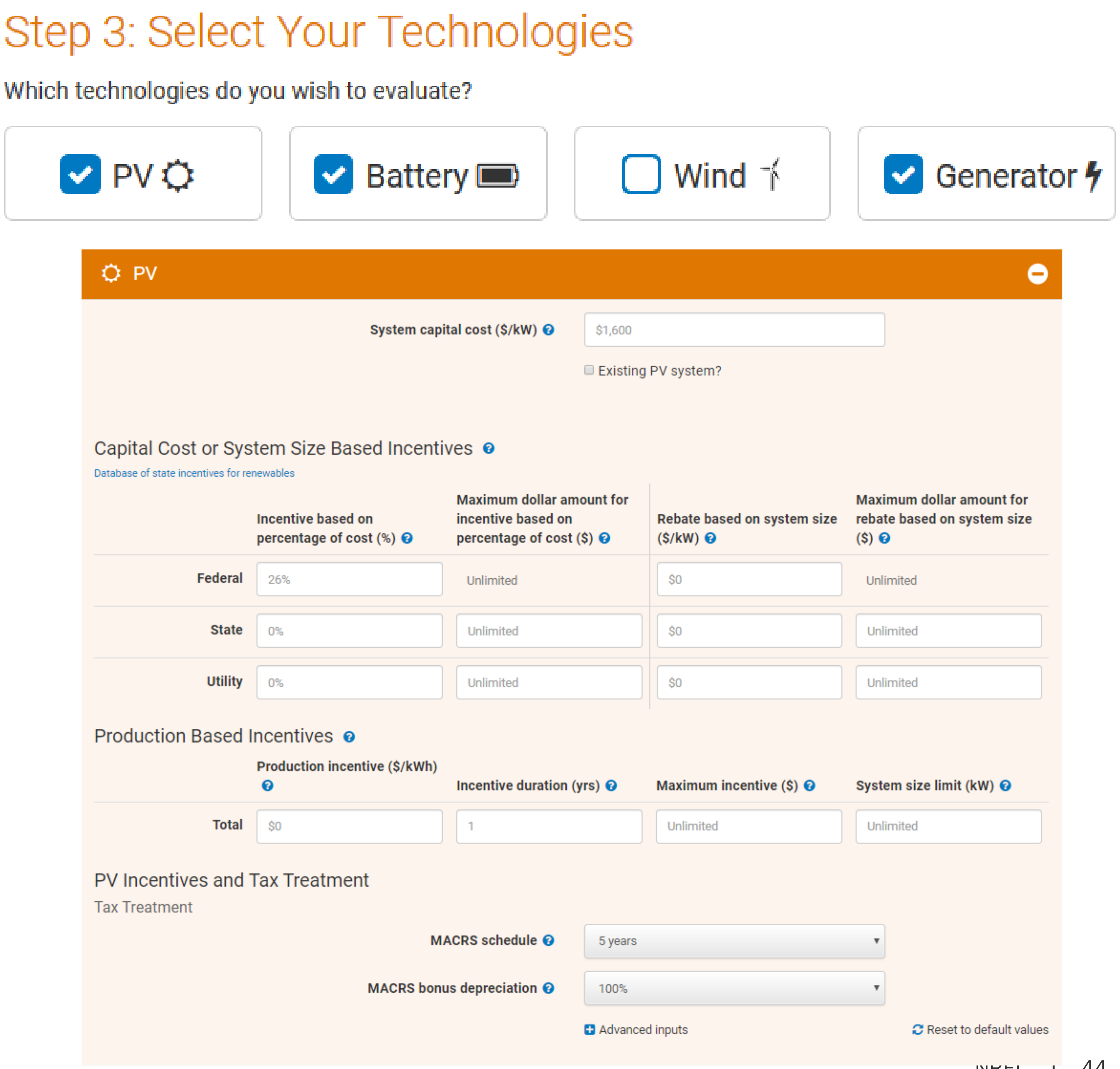


What load needs to be met during the outage?

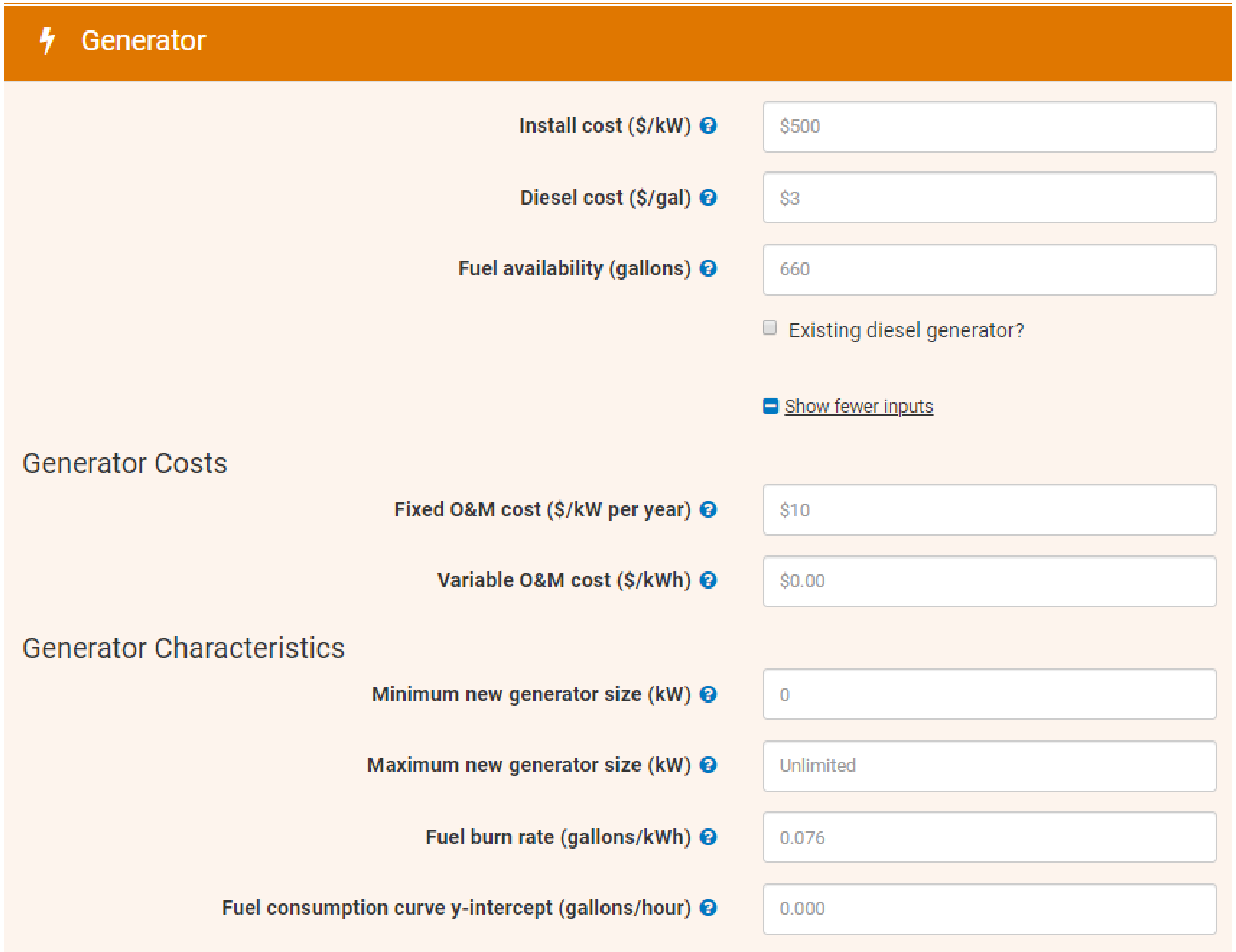
Outage scenario to model

Tech Modeling

- User selects technologies of interest
- Heavily populated with defaults
- Expandable menus to allow user adjustments of defaults
- Backup generator option for resilience evaluation



Backup Generator Modeling



Specify existing generator, and/or let REopt Lite size it

Defaults are for diesel generator but can be modified

Resilience Outputs

	Business As Usual	Resilience
System	None	18 kW Diesel 389 kW PV 96 kW Battery 412 kWh Battery
NPV	$0	$191,019
Survives Specified Outage	No	Yes
Average	0 hrs	531 hrs
Minimum	0 hrs	0 hrs
Maximum	0 hrs	1,885 hrs
Diesel Generator Fuel Used	0 gal	44 gal

Your recommended solar installation size

389 kW
PV size

Measured in kilowatts (kW) of direct current (DC), this recommended size minimizes the life cycle cost of energy at your site.

This optimized size may not be commercially available. The user is responsible for finding a commercial product that is closest in size to this optimized size.

Your recommended battery power and capacity

96 kW
battery power

412 kWh
battery capacity

This system size minimizes the life cycle cost of energy at your site. The battery power (kW-AC) and capacity (kWh) are optimized for economic performance.

This optimized size may not be commercially available. The user is responsible for finding a commercial product that is closest in size to this optimized size.

Your recommended generator size

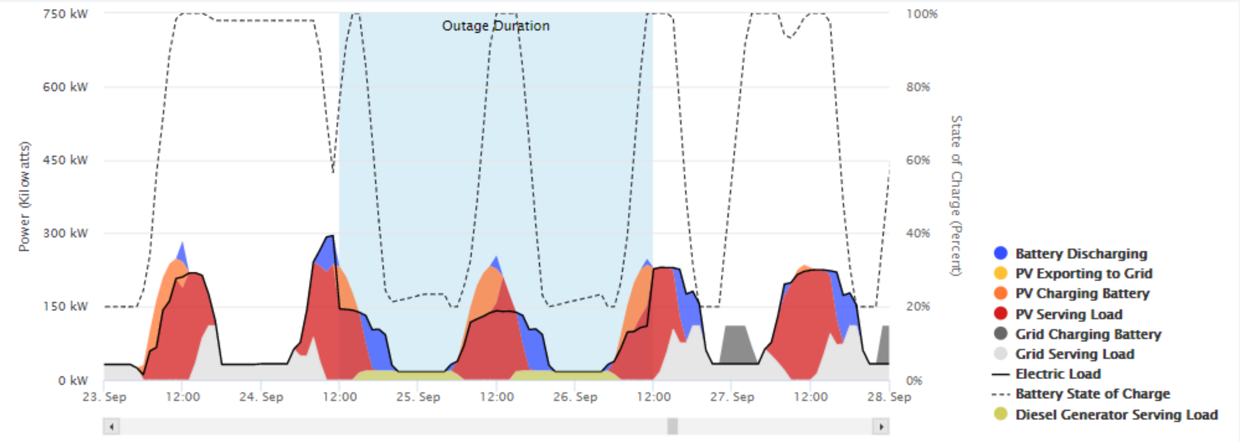
18 kW
generator size

Measured in kilowatts (kW) of alternating current (AC), this recommended generator size minimizes the life cycle cost of energy at your site during a grid outage.

This optimized size may not be commercially available. The user is responsible for finding a commercial product that is closest in size to this optimized size.

System Performance Year One

This interactive graph shows the dispatch strategy optimized by REopt Lite for the specified outage period as well as the rest of the year. To zoom in on a date range, click and drag right in the chart area or use the "Zoom In a Week" button. To zoom out, click and drag left or use the "Zoom Out a Week" button.



Zoom Out a Week | Zoom In a Week

Download Dispatch Spreadsheet

Resilience Outputs

A non-outage / 'Financial' scenario is run at the same time to allow the user to compare the differences between Resilient and Financial scenarios

Results Comparison

These results show how doing business as usual compares to the optimal case.

	Business As Usual	Resilience	Financial
System Size, Energy Production, and System Cost			
PV Size	0 kW	389 kW	361 kW
Annualized PV Energy Production	0 kWh	620,696 kWh	577,409 kWh
Battery Power	0 kW	96 kW	78 kW
Battery Capacity	0 kWh	412 kWh	253 kWh
Generator Size	0 kW	18 kW	0 kW
Net CAPEX + Replacement + O&M	$0	$649,198	$532,744
Energy Supplied From Grid in Year 1	992,952 kWh	403,791 kWh	448,266 kWh
Year 1 Utility Cost — Before Tax			
Utility Energy Cost	$74,050	$27,637	$31,430
Utility Demand Cost	$79,758	$38,484	$45,853
Utility Fixed Cost	$5,551	$5,551	$5,551
Utility Minimum Cost Adder	$0	$0	$0
Life Cycle Utility Cost — After Tax			
Utility Energy Cost	$709,556	$264,826	$301,166
Utility Demand Cost	$764,250	$368,763	$439,375
Utility Fixed Cost	$53,191	$53,191	$53,191
Utility Minimum Cost Adder	$0	$0	$0
Total System and Life Cycle Utility Cost — After Tax			
Total Life Cycle Costs	$1,526,998	$1,335,979	$1,326,476
Net Present Value	$0	$191,019	$209,418

Resilience Outputs

Your Potential Resilience

This system sustains the 50% critical load during the specified outage period, from September 24 at 12 pm to September 26 at 12 pm.

✔ System survives specified 48-hour outage

This system sustains the critical load for 83% of all potential 48 hour outages throughout the year.

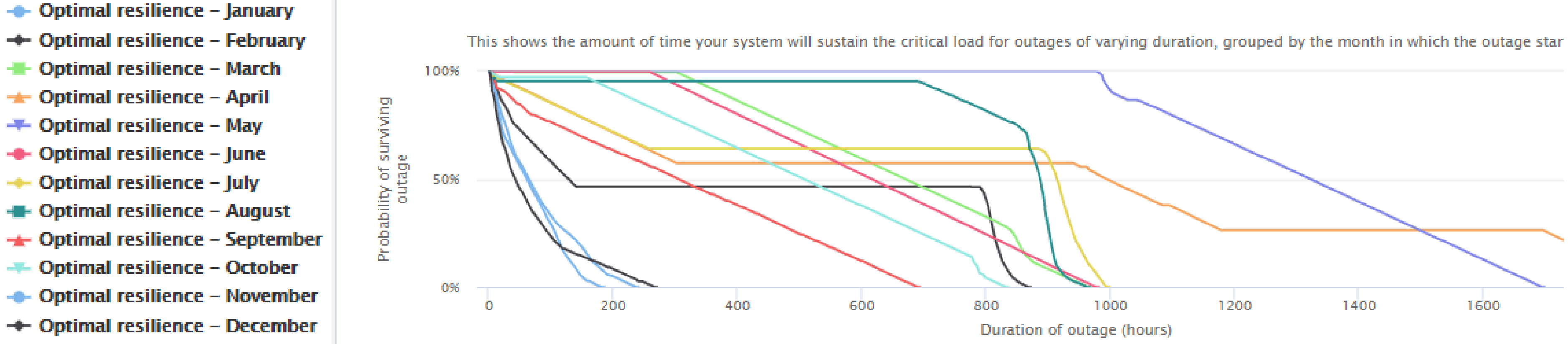
83% System survives 83% of 48-hour outages

REopt Lite optimizes system size and dispatch to survive specified outage

Outage Simulation

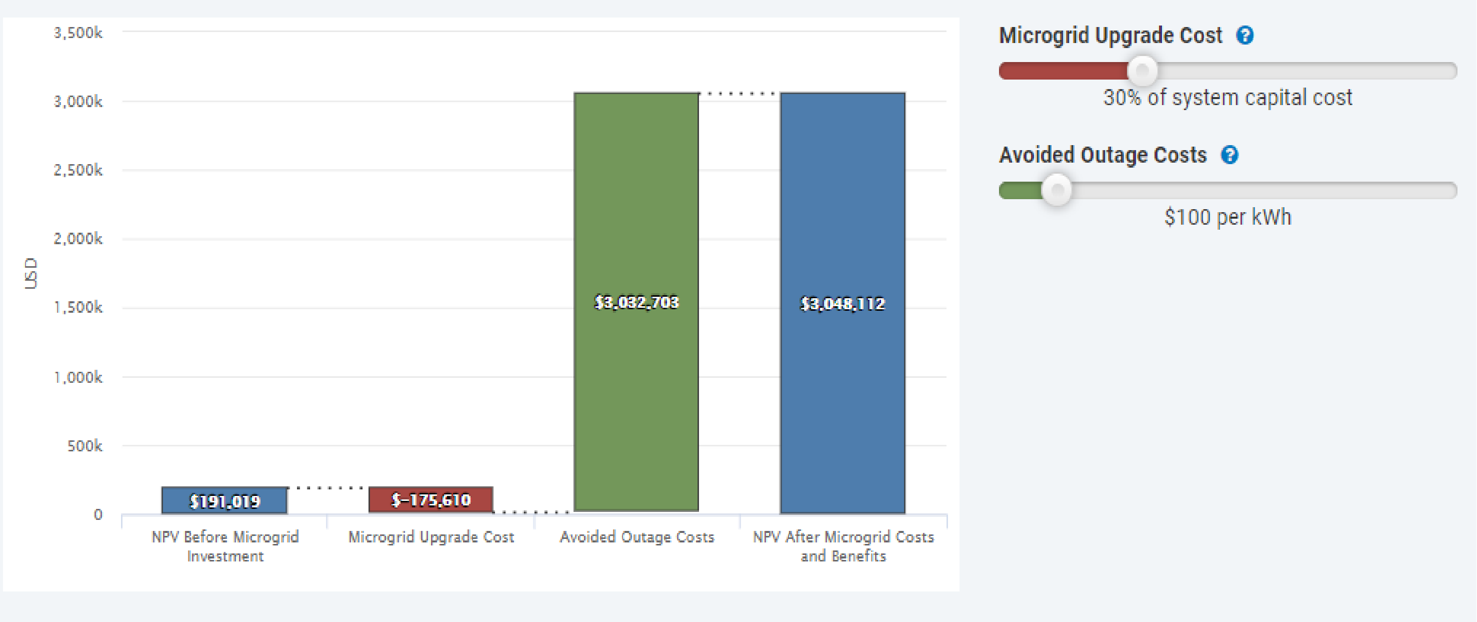
Evaluate the amount of time that your system can survive grid outages.

Yearly | Monthly | Hourly



REopt Lite simulates outages of varying length throughout the year

Resilience Outputs



- The site owner’s cost of the outage is not considered in the optimization
- Additional costs for developing a microgrid are not included in the default costs
- Sliders allow the impact of both of these on a potential project’s NPV to be explored

Making Use of Results

- Optimization formulation is powerful
- Limitations:
  - Lots of default assumptions that a beginner may not adjust
  - Model has perfect knowledge
- Usefulness of results:
  - Develop an understanding of the impact of RE resources, economic drivers, potential technology mix and how they interact/complement/compete with each other
  - For non-experts, results useful to inform discussions with system integrators and expert consultants

FY20 Development Plans

- **Third-party financing:** Develop a financial model for third-party ownership of photovoltaic, wind, or battery systems
- **Federal scenarios:** Create analysis assumptions and results for federal users
- **Run comparison:** Compare results from different REopt Lite scenarios
- **Utility rates:** Add features such as ratchets and peak load contribution
- **Constraints:** Add ability to constrain solution based on budget, emissions, and renewable energy goals
- **Combined heat and power:** Integrate a combined heat and power technology option
- **Online user forum:** Allow users to ask and respond to questions, share insights, and successes
- **Electric vehicles:** Add option to include electric vehicle loads in optimizations
- **Open source:** Release REopt Lite open source software
- **Additional resources:** Add new REopt Lite case studies and tutorials

Resources

- REopt Lite Web Tool:
  - Web tool: https://reopt.nrel.gov/tool
  - Help manual: https://reopt.nrel.gov/user-guides.html

- REopt Lite Tutorials on the NREL YouTube Learning Channel: https://www.youtube.com/playlist?list=PLmIn8Hncs7bF4UNN7hGlhZ0UohbI4-c4b

- REopt Lite API: https://developer.nrel.gov/docs/energy-optimization/reopt-v1/
  - Information to access API
  - User guide

- REopt Website: https://reopt.nrel.gov/
  - Case studies
  - Analysis services

Thank You

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www.nrel.gov

REopt Lite

- REopt Lite (tool and help manual): https://reopt.nrel.gov/tool
- REopt Website (analysis services and case studies): https://reopt.nrel.gov/tool
- Send tool feedback & ask a question: reopt@nrel.gov

NREL Transforming ENERGY

Break

- Resume at 10:15

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CHP Integration with Renewables in Microgrids

Neeharika Naik-Dhungel, EPA CHP Partnership

NARUC-NASEO Microgrid State Working Group Roundtable, February 2020.

EPA Combined Heat and Power Partnership

Origins and Focus Launched in 2001. Goal to reduce the environmental impact of energy generation by promoting higher efficiencies. The Partnership is technology, fuel and vendor neutral.

Audience EPA CHP Partners: Industrial, commercial, institutional energy users, Project developers, Equipment manufacturers, Gas and electric utilities, State, city, and local agencies, NGOs and industry associations

Resources, Outreach and Engagement Unbiased resources of CHP technologies, project development, policy portal, and emissions and energy savings estimator tool. Increasing focus on the role of CHP in microgrids, resiliency and grid integration as it plays a role in the energy trilemma.

CHP Energy and Emissions Calculator

Microgrid Case Study Considered

- City of Milford, CT– under development (will integrate PV + CHP)

Energy and Emissions Estimator Tool

- The CHP Emissions Calculator calculates the difference between the anticipated CO_2, methane (CH_4), nitrous oxide (N_2O), SO_2, and NO_x emissions from a CHP system to those of a separate heat and power system.
- The Calculator uses fuel specific CO_2, CH_4 and N_2O emissions factors from the EPA's GHG Reporting Program, region specific Transmission & Distribution (T&D) loss values, and data from eGRID 2012.

Overview of Emissions Estimation Methodology

- Type of inputs required –
  - CHP or solar electric capacity (kW)
  - Annual hours of operation
  - CHP fuel type
  - CHP thermal energy use: heating, cooling or both
  - Whether there is emissions control equipment (+ NOx emissions rate if there are controls)
- CHP/RE integration component details –
  - Conducted individual runs of the Emissions Calculator for each technology type (e.g., 1 run for the CHP system, 1 run for the PV systems)
  - Added the emissions calculator results from the individual technology runs for each microgrid project together.
    - For the CHP system took the overall emissions results from the Calculator
    - For the PV systems only counted the displaced electricity production results (did not include the CHP system or the displaced thermal production results)

Case Study – City of Milford, CT

Proposal an outcome of CT DEEP Round 2 Microgrid Program (October 2014)

- 5 facilities will have the ability to operate independently of the UI grid
  - Parsons Center
  - Milford Senior Center
  - Harborside Middle School
  - City Hall
  - River Park Senior Apartments

Microgrid components

- Two 146 kW natural gas-fired reciprocating engine CHP systems will replace the existing outdated boilers in the Parsons Center.
- A photovoltaic array accompanied by battery energy storage will help offset the daytime electric load.
- The PV system will be located in a parking lot adjacent to the Parsons Center and will provide supplemental power during the daylight periods.
- The necessary electrical and controls infrastructure will tie these buildings together as a microgrid that will operate in parallel with the utility grid.

Case Study 2 – City of Milford Inputs

	CHP System 1
Type of CHP System	**NG-Fired Reciprocating Engine**
CHP Electric Capacity (kW)	292 kW
Annual Hours of Operation	8,322 (95% availability)
CHP Fuel Type	Natural Gas
Thermal Energy: Heating, Cooling, or Both?	Heating
Hours in Cooling Mode?	NA
Emissions Control Equipment? (yes/no)	Yes
If Yes, what is NOx emission rate? (ppm, or lb/MWh)	0.15 lb/MWh
What type of thermal system was displaced?	Existing boilers
Fuel Type of Displaced Thermal System	Natural Gas

	Solar PV Array
Electric Capacity (kW)	120 kW
Annual Hours of Operation, or Capacity Factor	1,555

Case Study 2 – City of Milford Results

CHP System Results Annual Emissions Analysis					
	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO_x (tons/year)	0.18	1.08	1.01	1.90	91%
SO_2 (tons/year)	0.01	1.92	0.01	1.92	100%
CO_2 (tons/year)	1,728	1,796	1,181	1,249	42%
CH_4 (tons/year)	0.03	0.057	0.02	0.047	59%
N_2O (tons/year)	0.00	0.021	0.00	0.020	86%
Total GHGs (CO_2e tons/year)	1,730	1,804	1,182	1,256	42%
Fuel Consumption (MMBtu/year)	29,568	23,296	20,204	13,932	32%
Equal to the annual GHG emissions from this many passenger vehicles:				238	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				156	

PV Results Annual Emissions Analysis					
	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NO_x (tons/year)	-	0.08	-	0.08	100%
SO_2 (tons/year)	-	0.15	-	0.15	100%
CO_2 (tons/year)	-	136	-	136	100%
CH_4 (tons/year)	-	0.004	-	0.004	100%
N_2O (tons/year)	-	0.002	-	0.002	100%
Total GHGs (CO_2e tons/year)	-	137	-	137	100%
Fuel Consumption (MMBtu/year)	-		-	1,765	100%
Equal to the annual GHG emissions from this many passenger vehicles:				26	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				17	

Case Study 2 – City of Milford Combined Results (CHP + PV)

CHP + PV Results Annual Emissions Analysis					
	CHP System (CHP only)	Displaced Electricity Production (CHP + PV combined)	Displaced Thermal Production (CHP only)	Emissions/Fuel Reduction (CHP + PV combined)	Percent Reduction (CHP + PV combined)
NO_x (tons/year)	0.18	1.16	1.01	1.98	91%
SO_2 (tons/year)	0.01	2.07	0.01	2.07	100%
CO_2 (tons/year)	1,728	1,932	1,181	1,385	44%
CH_4 (tons/year)	0.03	0.061	0.02	0.051	61%
N_2O (tons/year)	0.00	0.023	0.00	0.022	87%
Total GHGs (CO_2e tons/year)	1,730	1,941	1,182	1,393	45%
Fuel Consumption (MMBtu/year)	29,568	23,296.36	20,204	15,697	32%
Equal to the annual GHG emissions from this many passenger vehicles:				264	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				173	

Summary

- Current tool is a simple educational tool. Provides an overview while DOE models provide depth.
- Current tool to be updated to include key renewables for which CHP is a grid-balancing, dispatch-flexibility resource.

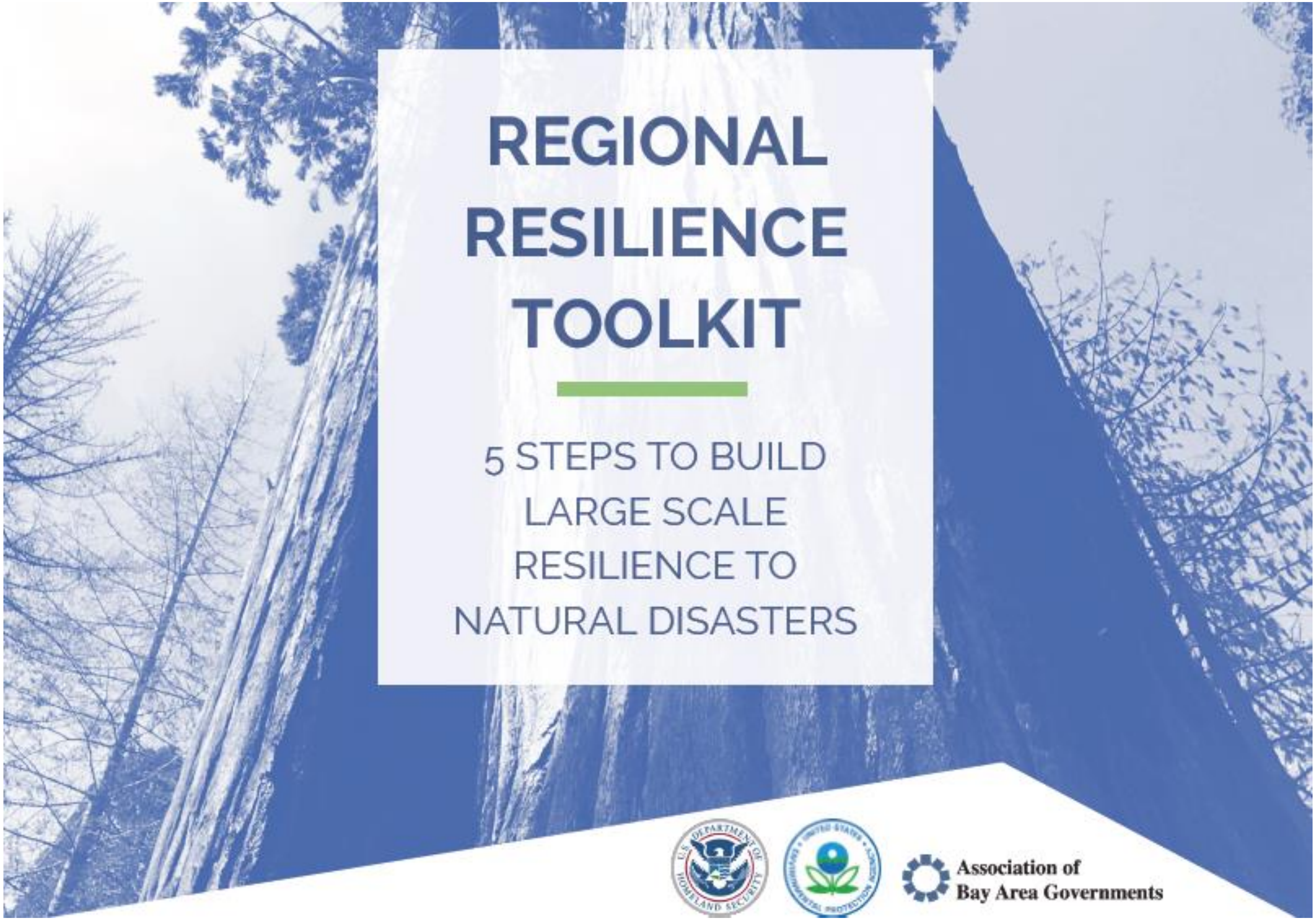
Contact Information

Neeharika Naik-Dhungel
Naik-Dhungel.Neeharika@epa.gov

CHPP Website : www.epa.gov/chp

CHPP Help Line: 703/373-3108

EPA CHP COMBINED HEAT AND POWER PARTNERSHIP


REGIONAL
RESILIENCE
TOOLKIT
5 STEPS TO BUILD
LARGE SCALE
RESILIENCE TO
NATURAL DISASTERS
Association of
Bay Area Governments

Partnership between EPA & FEMA

FEMA

- Sets up coordination of activities between EPA's community technical assistance programs and FEMA's disaster recovery planning and hazard mitigation programs.
- Seeks to provide lessons learned for EPA, FEMA, and other federal agencies that can be used to build a stronger federal framework for mitigation planning as well as post-disaster recovery planning and operations.
- Seeks to provide a collaborative framework for policy work related to both hazard mitigation planning and climate change adaptation to create more resilient communities.

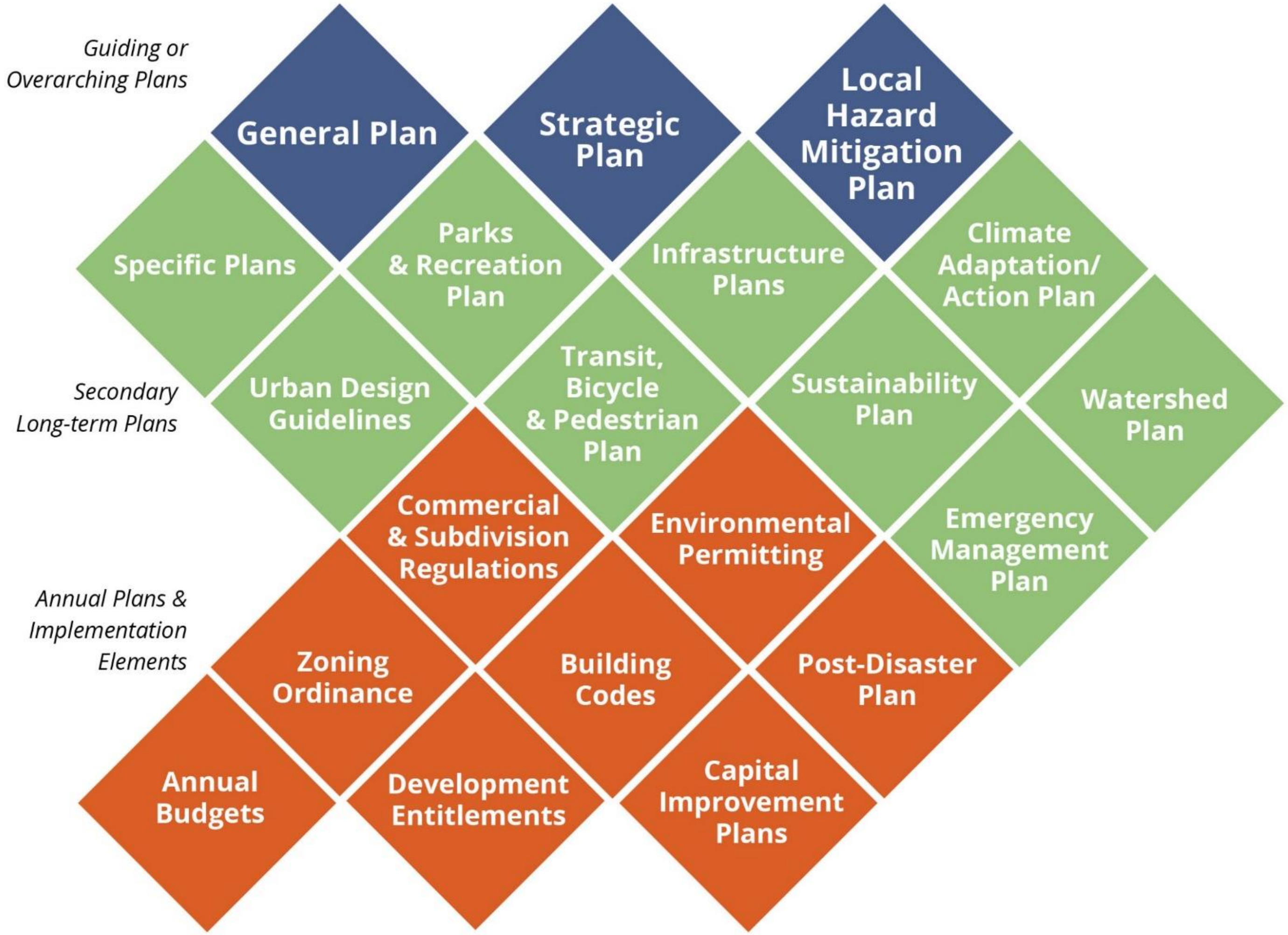
https://www.epa.gov/smartgrowth/smart-growth-strategies-disaster-resilience-and-recovery

Resilience is about building
the capacity of the community
to prepare for, withstand, recover, and maintain
its identity
in the face of current or future hazards.

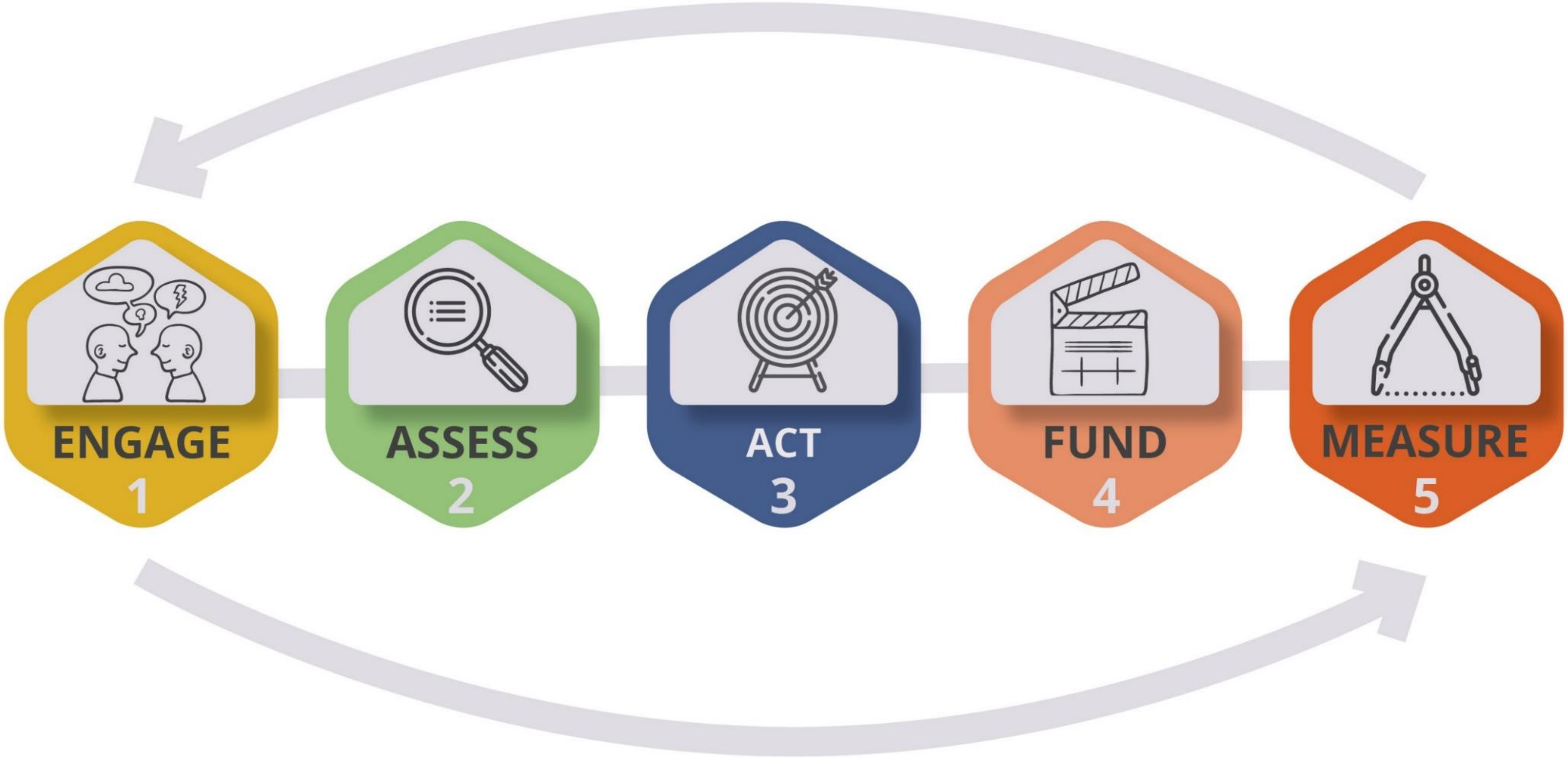
Quick Overview of the Toolkit

- Regional scale is key. Works across multiple communities over a large geographic region
- Recognizes local authority for implementing plans and spending funds
- Addresses different hazards
- Applies to different assets
- Aligns with different plan requirements
  - FEMA Local Hazard Mitigation Plan requirements

Toolkit is online at
www.epa.gov/smartgrowth/regional-resilience-toolkit



Guiding or Overarching Plans
Secondary Long-term Plans
Annual Plans & Implementation Elements
General Plan
Strategic Plan
Local Hazard Mitigation Plan
Specific Plans
Parks & Recreation Plan
Infrastructure Plans
Climate Adaptation/ Action Plan
Urban Design Guidelines
Transit, Bicycle & Pedestrian Plan
Sustainability Plan
Watershed Plan
Commercial & Subdivision Regulations
Environmental Permitting
Emergency Management Plan
Zoning Ordinance
Building Codes
Post-Disaster Plan
Annual Budgets
Development Entitlements
Capital Improvement Plans


ENGAGE
1
ASSESS
2
ACT
3
FUND
4
MEASURE
5

Two Appendices

- Appendix A has resources for each step.

- Appendix B has worksheets for each of the five steps.

STEP 1: ENGAGE

- Build Trust
- Importance of Equity
- Common Terms
- Mapping Partners
- Meeting Roadmap

STEP 2: ASSESS

- What's Your "Trigger"?
- Set Resilience Goals
- Describe Hazards
- Develop Hazard Impact Statements
- Prioritize Hazards
- Select Assets
- Summarize the asset and vulnerabilities

STEP 3: ACT

- Develop and prioritize strategies (plans, regs, projects, education, policy, etc.)
- Pick strategies you can pull off!
- Write Implementation Plans
  - Short term actions
  - Long term strategies

3.3 Evaluation Criteria

Criteria	Strategy 1	Strategy 2	Strategy 3	Strategy 4	Strategy 5
FEASIBILITY Funding: With existing or expected funding sources					
Political support*: Likelihood of political support					
Local champion***:** Supported by a strong advocate or local champion					
Administrative*: With existing operations or procedures					
Technical*: With existing technology or know how					
Legal*: With existing authorities or policies					
SOCIAL BENEFITS Access: Protects access to jobs or services					
Life safety: Protects residents lives and prevents injuries					
Awareness: Increases public awareness					
Vulnerable residents: Protects especially vulnerable community members					
Recreation: Maintains recreational or educational opportunities					
ECONOMIC BENEFITS Jobs: Promotes/retains jobs					
Commuter movement: Maintains commuter movement					
Reduces disruption: Reduces service or network disruptions					
Reduces damages*: Reduces asset damage, e.g. to structures, infra-structure					
ENVIRONMENTAL IMPROVEMENT*					

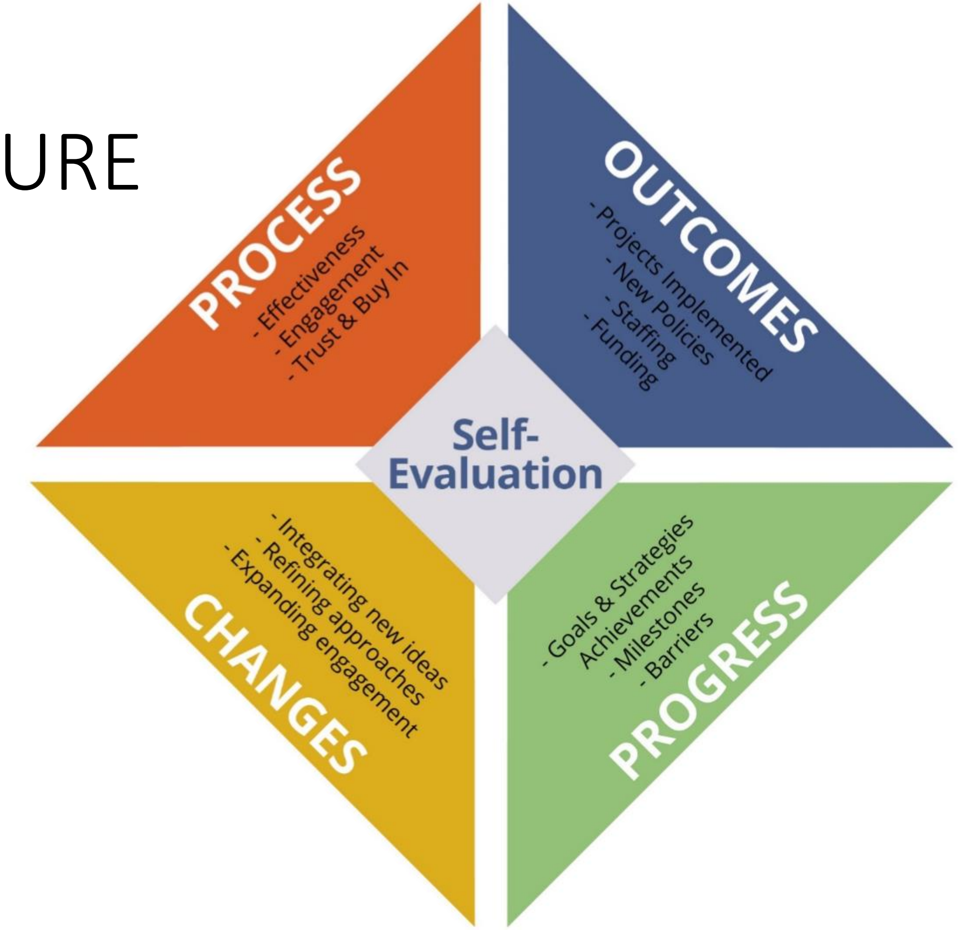
STEP 4: FUND

- Learn how to “sell” your projects
- Build your network of funders
- Look at local budgets, bonds, and taxes
- Look at a range of funding sources
  - Public-private financing
  - Philanthropic and corporate grants
  - Regional funding programs
  - Federal and state grants

MEASURE
5

STEP 5: MEASURE

- What to Measure and Why
- Outputs vs. Outcomes
- Self-Evaluation
- Measure and Refine



Energy Resilience

- Mt. Shasta, CA pilot talked about the vulnerability of the electric grid to winter storms and fires, and an interest in setting up a microgrid around the community center.
- Community energy districts support community resilience by offering multiple benefits:
  - Energy independence from the grid during power outages;
  - Independent energy and water conservation and storage;
  - Cooling/warming centers for extreme heat and winter storms;
  - Reliability of critical services, evacuation centers, communication centers.
- Can come through pre-disaster planning or as part of recovery and rebuilding.

Thank you!

Contact:

Abby Hall: hall.abby@epa.gov

Michelle Madeley: madeley.michelle@epa.gov

Agenda (Day 2)

- 8:30 – 9:00 Welcome, Check-In, and Presentation from DOE OE
- 9:00 – 11:15 Federal Tools and Resources Presentations from Sandia, NREL, EPA, and LBNL
  - 9:00 – 9:30 Will McNamara, Sandia National Labs
  - 9:30 – 10:00 Dan Olis, National Renewable Energy Lab
  - 10:15 – 10:45 Neeharika Naik-Dhungel, Michelle Madeley, Abby Hall, EPA
  - 10:45 – 11:15 Nicholas DeForest, Lawrence Berkeley National Lab
- 11:15 – 11:30 Wrap-Up, Takeaways, Conclude

DER-CAM DECISION SUPPORT TOOL FOR DECENTRALIZED ENERGY SYSTEMS

ANALYTICS | PLANNING | OPERATIONS

Introduction to DER-CAM

Nicholas DeForest
Grid Integration Group, Berkeley Lab

BERKELEY LAB

Why DER & Microgrids?

Reduce Total Energy Costs

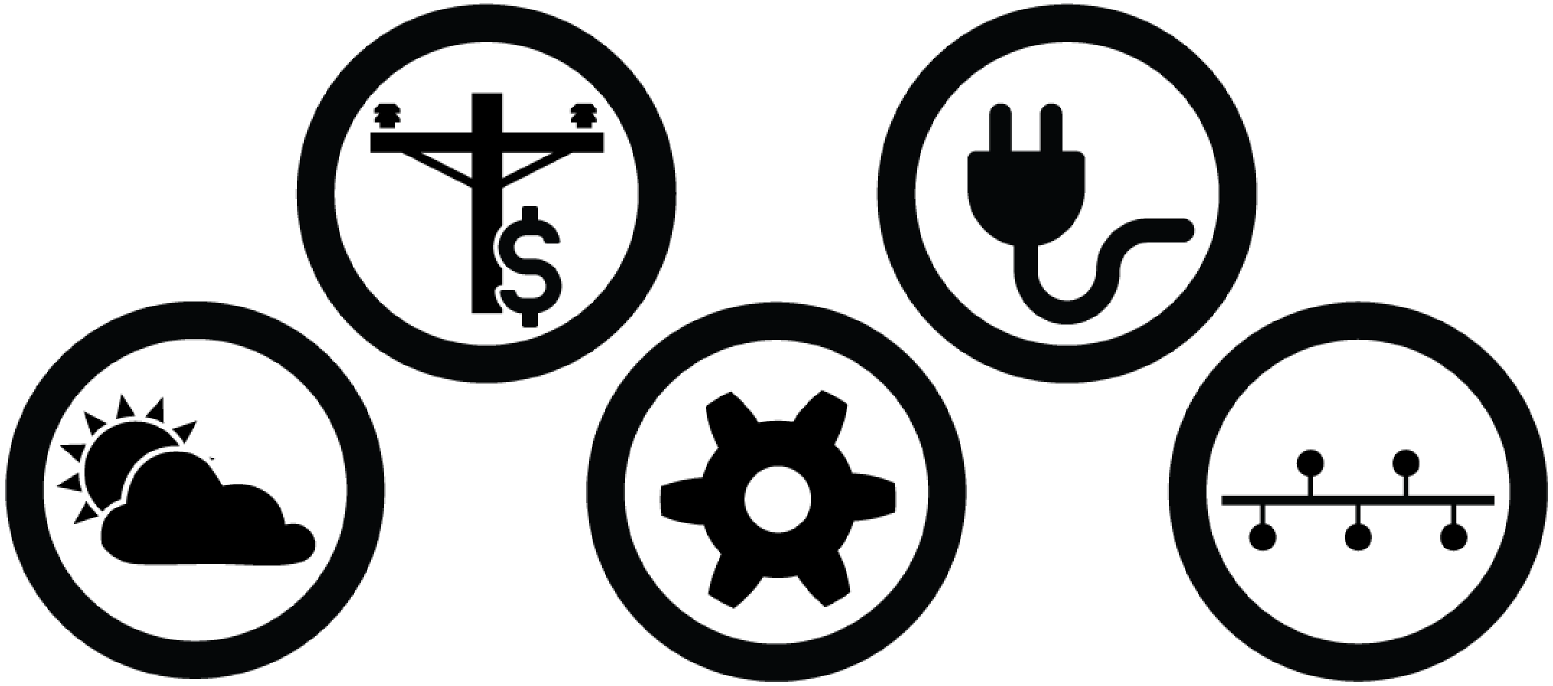
Reduce Total CO_2 Emissions

Reduce Outages & Ensure Energy Security

What Impacts a System’s Potential?

Utility Information & Tariffs

Consumption Profiles



Weather & Climate Data

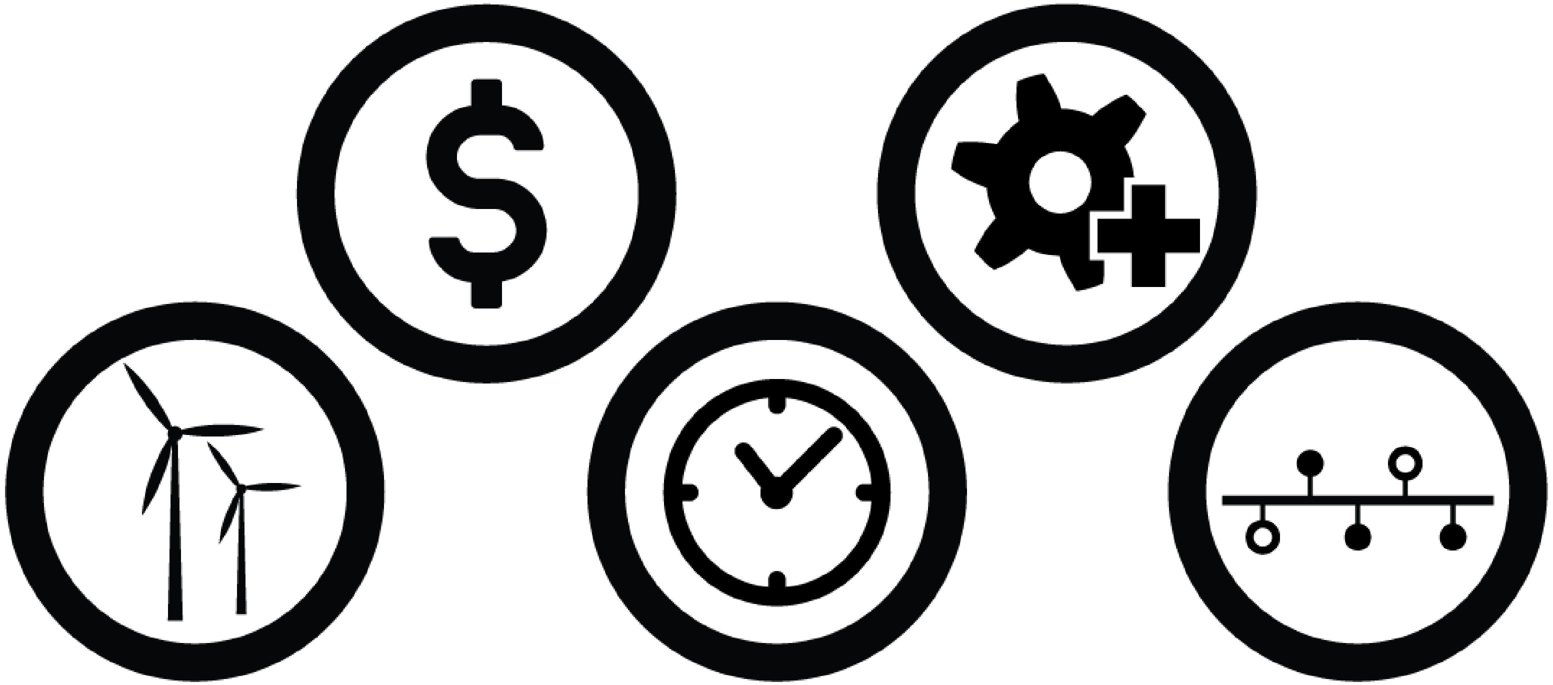
DER Technology Data

System Network Topology

What Guidance is Needed?

Cost & Performance Metrics

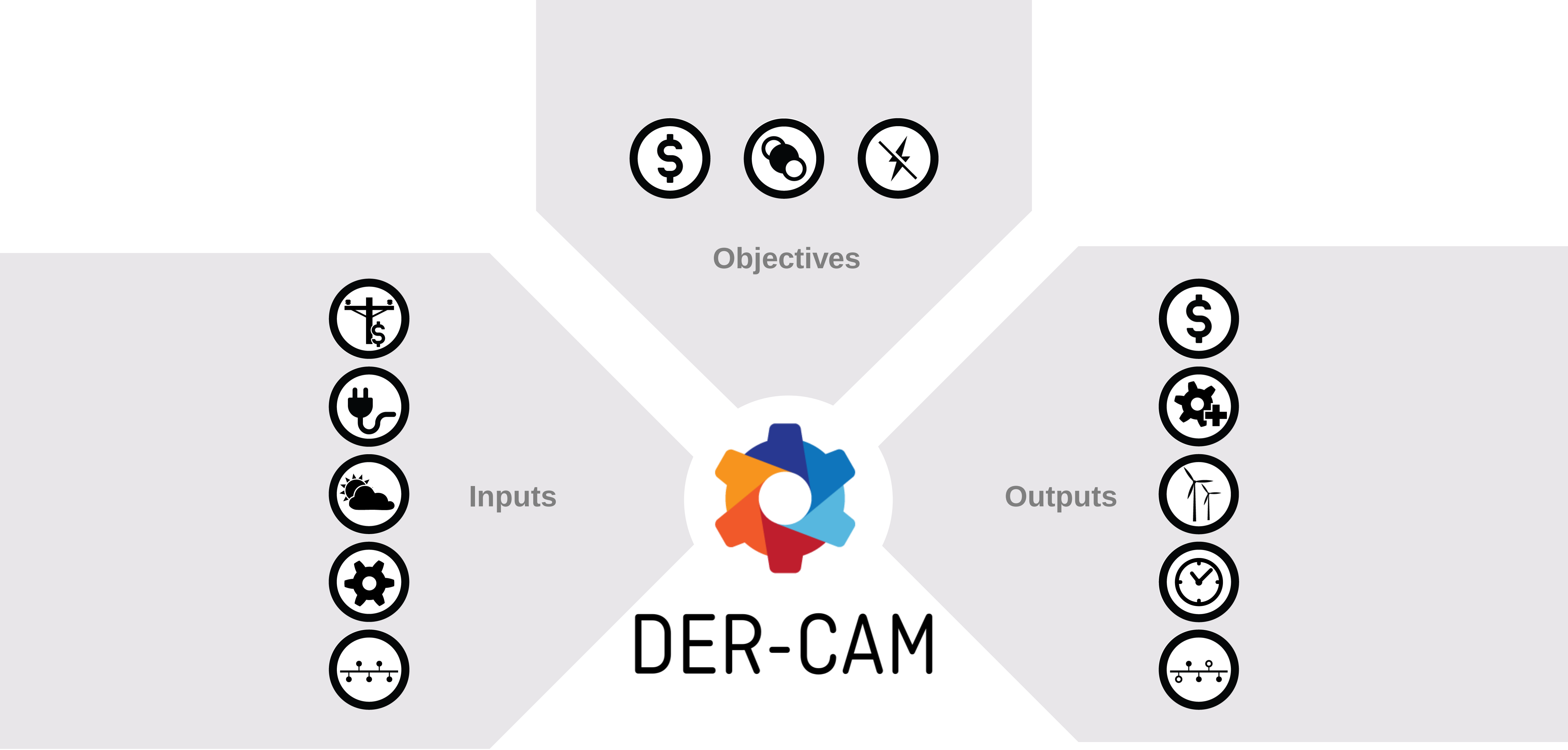
New Technology Investments

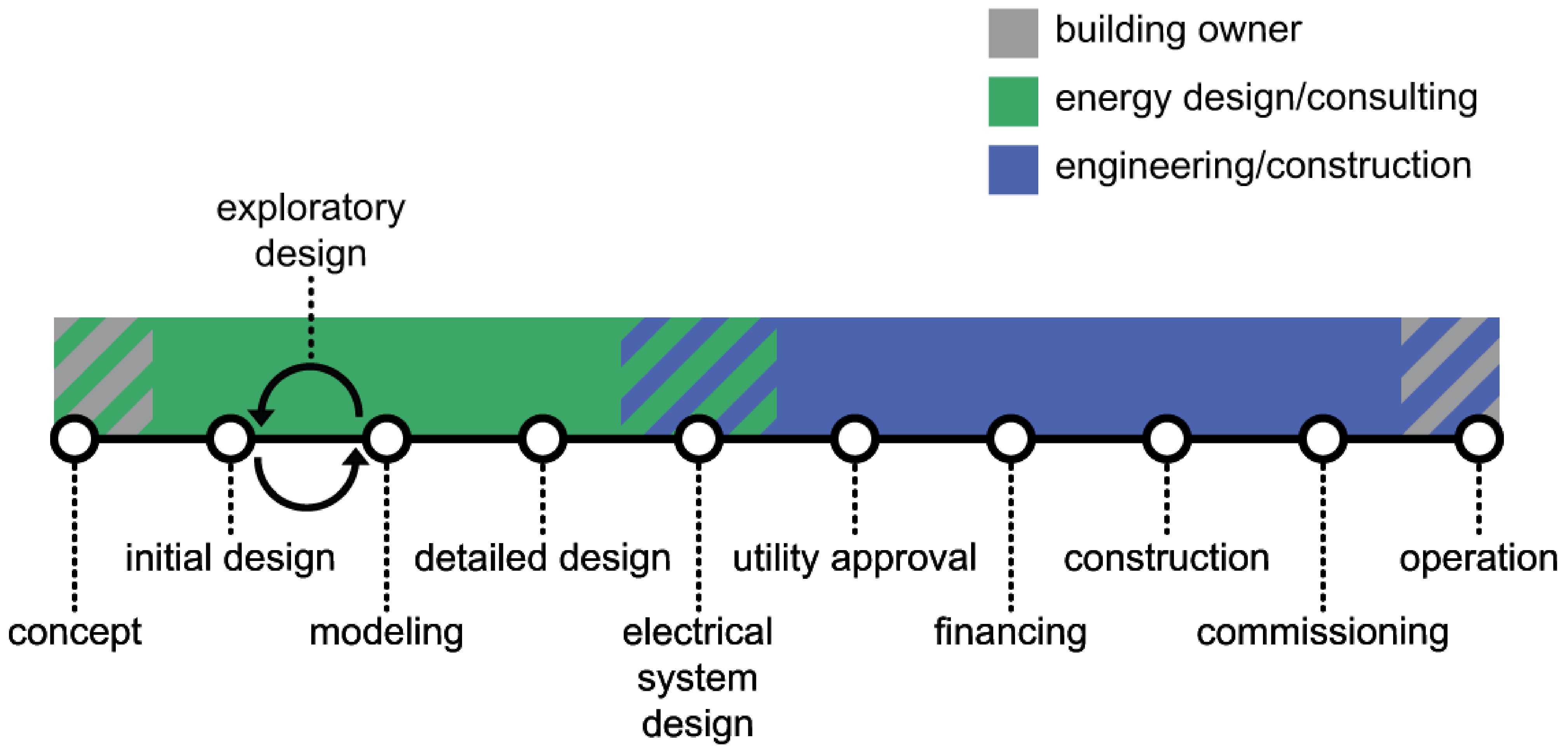


New Technology Capacity Sizing

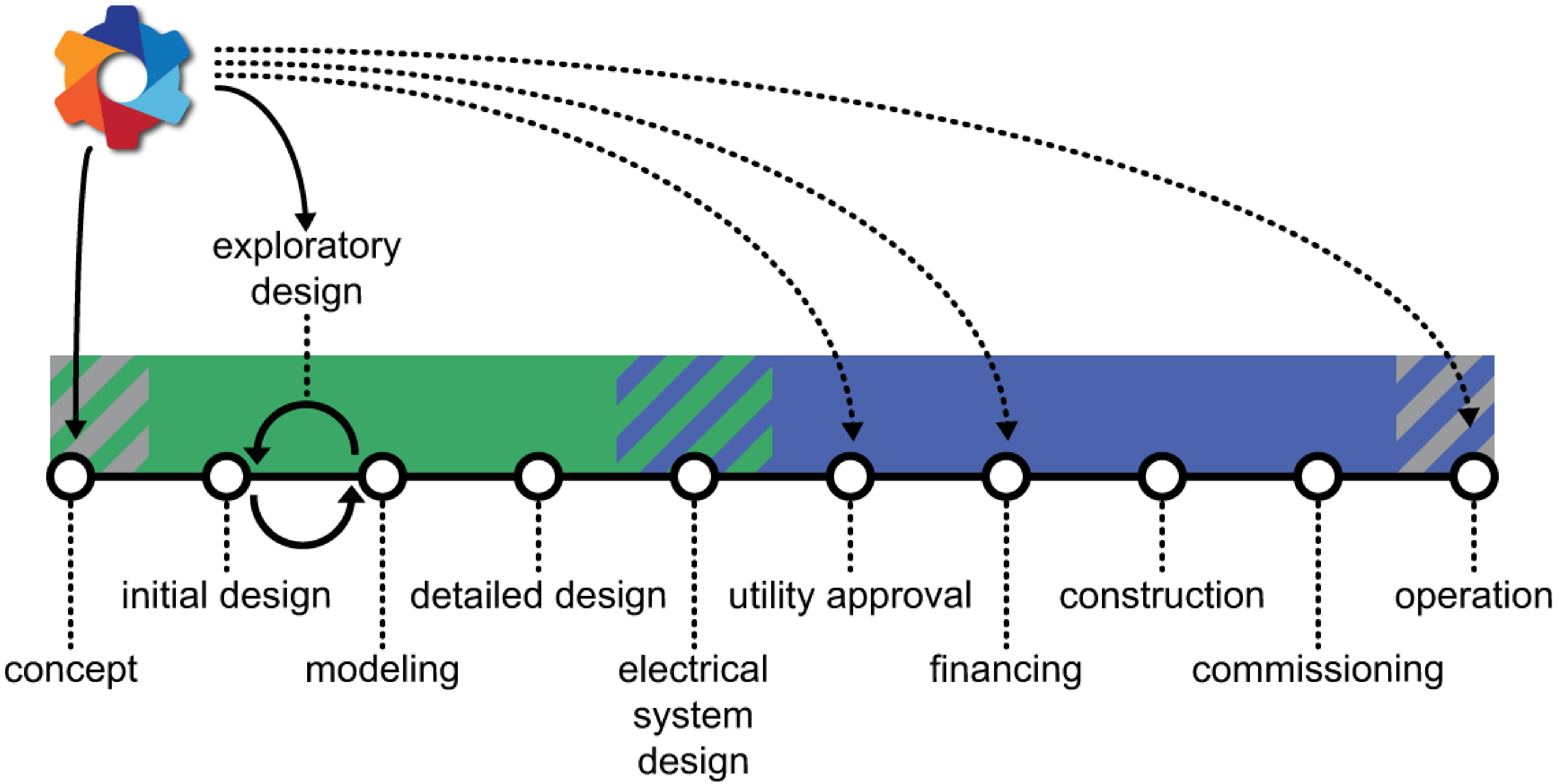
Operational Schedules

Placement Within Network


Objectives
Inputs
Outputs
DER-CAM



building owner
energy design/consulting
engineering/construction
exploratory design
initial design
detailed design
utility approval
construction
operation
concept
modeling
electrical system design
financing
commissioning


exploratory design
concept
initial design
modeling
detailed design
electrical system design
utility approval
financing
construction
commissioning
operation

DER-CAM

DER Technologies & Investments

Generation
- Solar PV
- Combined Heat & Power
  - Combustion Engines
  - Fuel Cells
  - Micro-turbines,
- Solar Thermal Panels
- Wind And Hydro Power

Energy Storage
- Battery Storage
- Heat Storage
- Chilled Water And Ice Storage
- Electric Vehicles

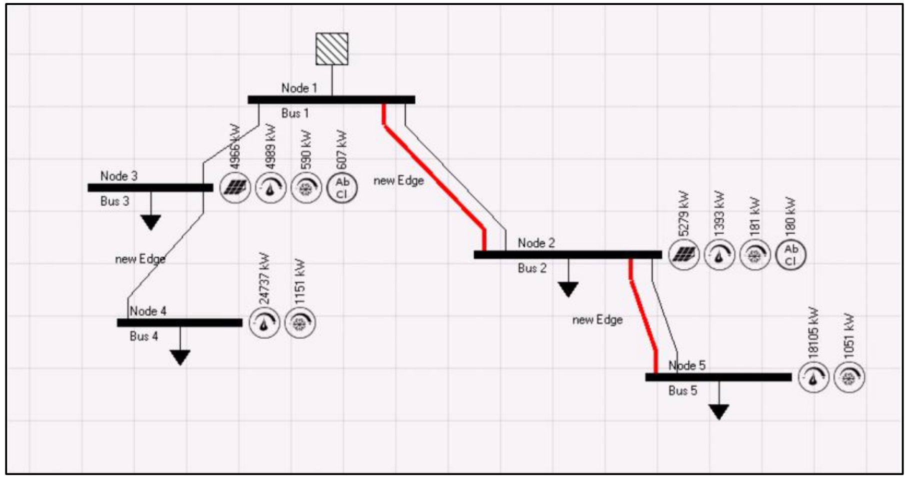
Load Management
- Demand Response
- Load Shifting
- Load Curtailment

Energy Efficiency Measures

DER-CAM

DER Value Streams

- Volumetric electricity purchases
- Monthly demand charges
- Electricity exports
- Demand response
- Ancillary services
- Reduced energy consumption
- Improved service efficiencies



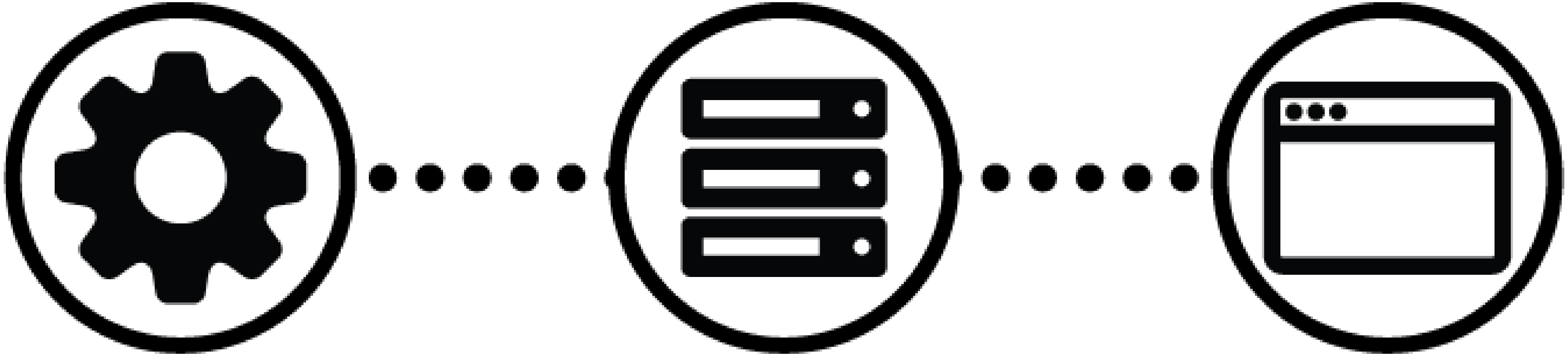
- Multi-building networked microgrids
- Heat and power flow modeling
- Multi-energy microgrids
- AC & DC microgrids
- N-1 security constrained designs

Advanced Features

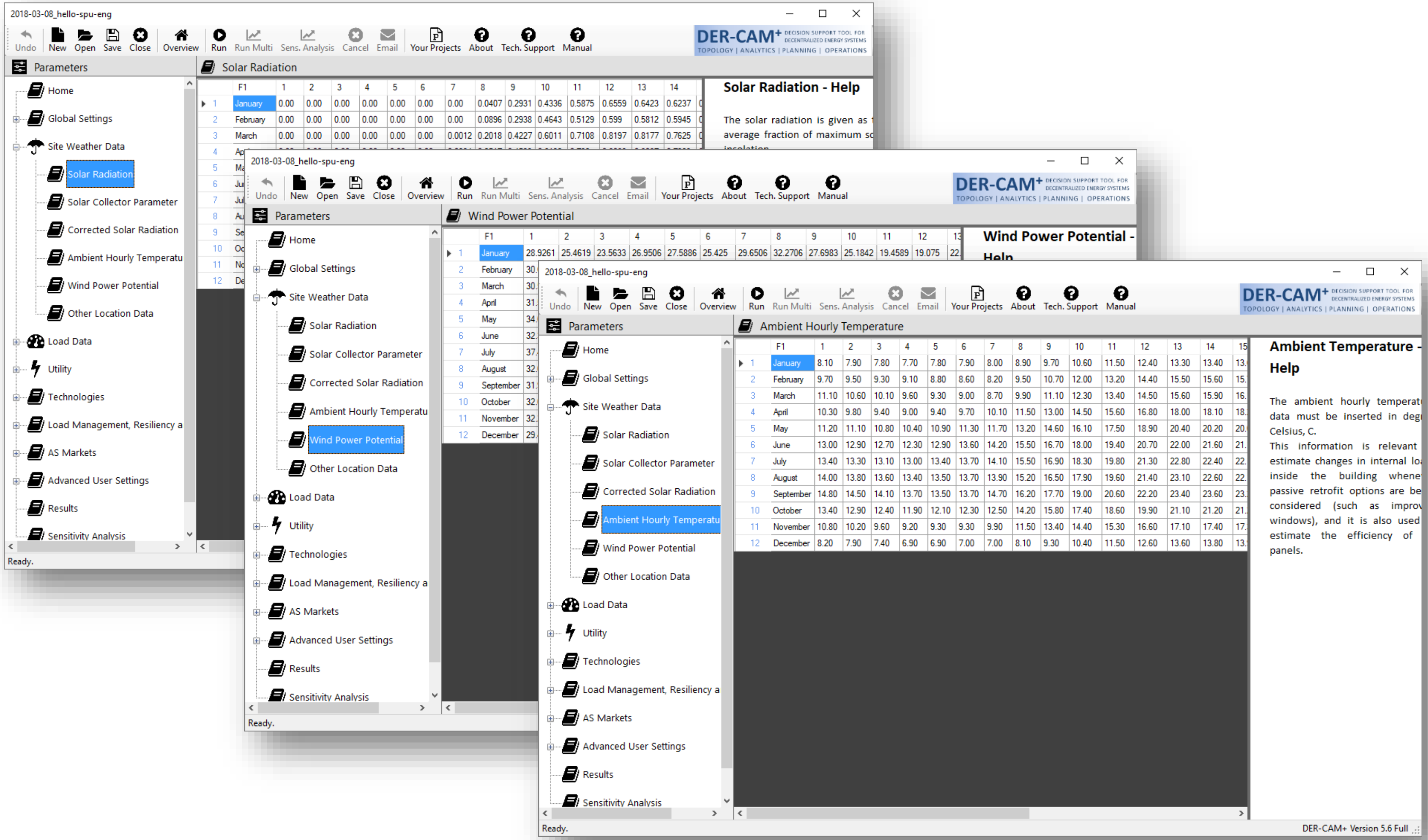
optimization engine

server

user interface



DER-CAM Desktop UI



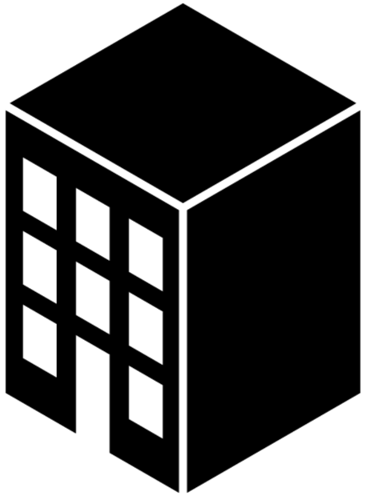
DER-CAM Data Resources

Reference building load profiles

Electricity tariff database

Typical insolation profiles

DER technology libraries



Quick Feasibility Studies

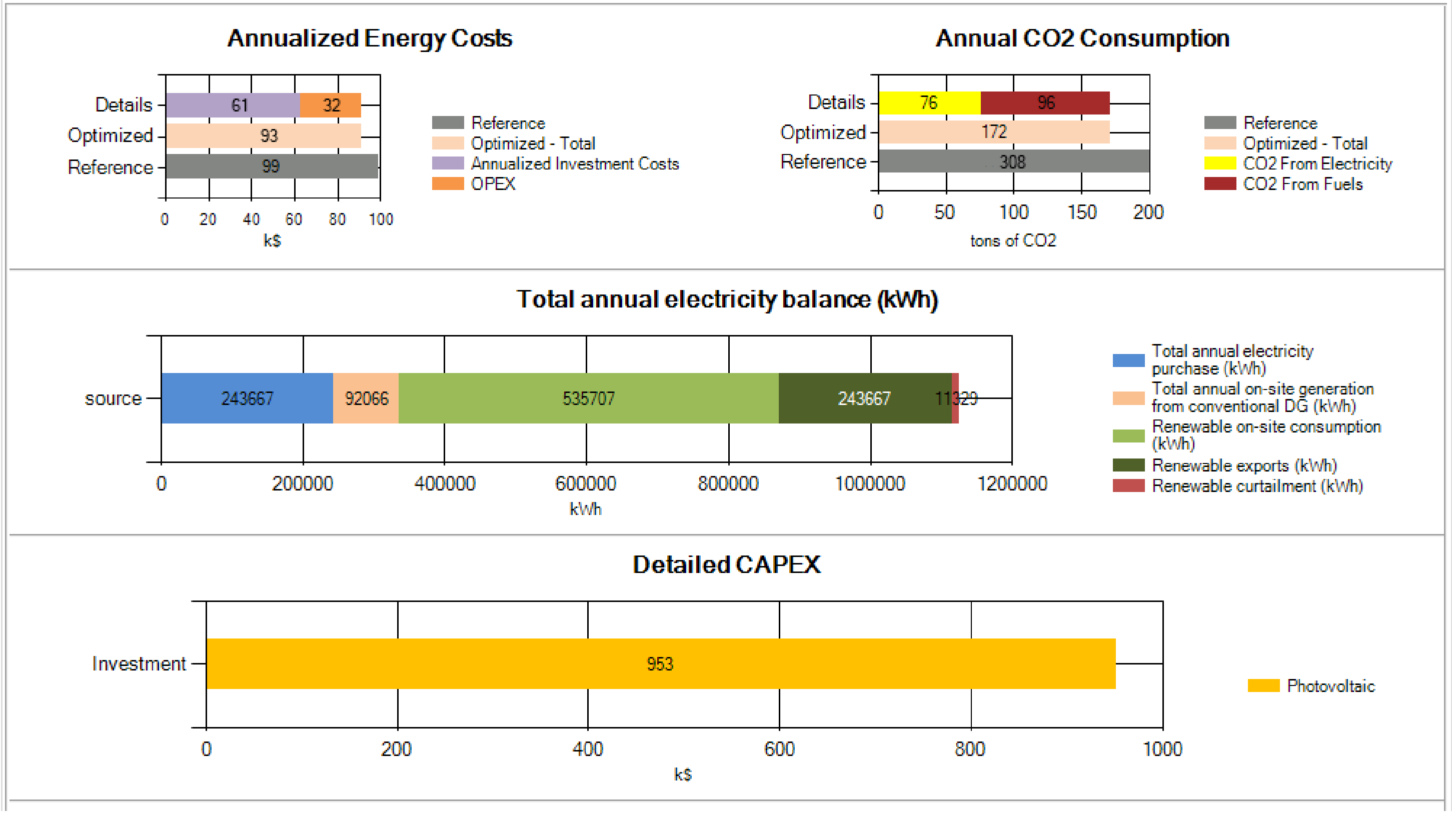
- Results

Summary | Electricity Dispatch | Heat Dispatch | Cooling Dispatch | Investment Decisions | Economic Results | Energy & Fuel Supply | Environmental Results | Detailed

Summary Table

	DER Solution	Reference	Total Savings (%)
Total Annual Energy Costs (k$)	93	99	6.1
Total Annual CO2 emissions (metric tons)	172	308	44

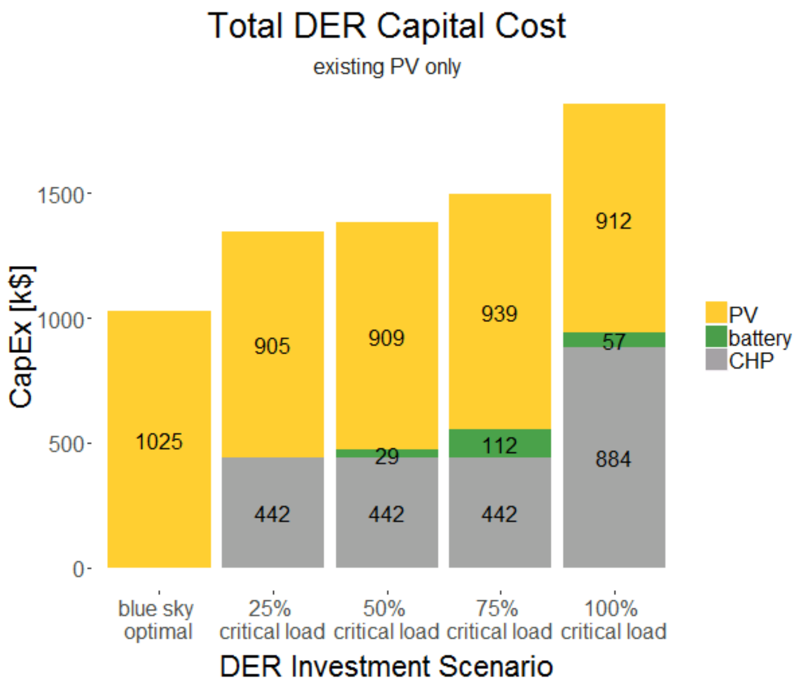
Charts Summary

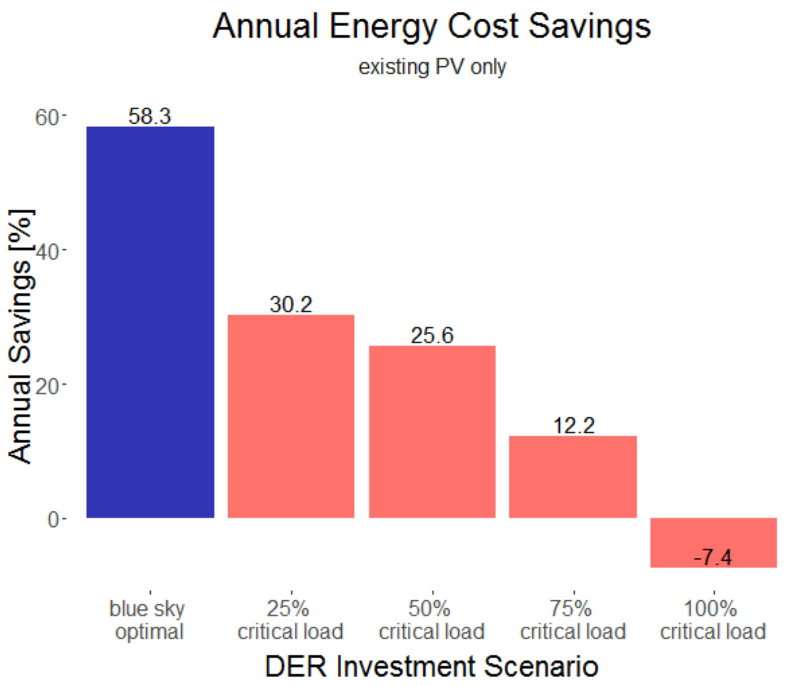


Scenario & Parametric Analysis

- DER Technologies & Costs
- Tariffs & Energy Rates
- Load Profiles
- Etc.

Resilience Modeling Scenario Analysis

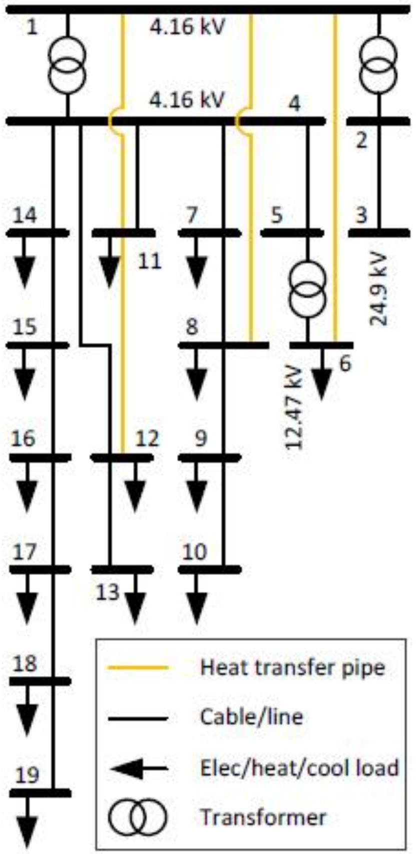


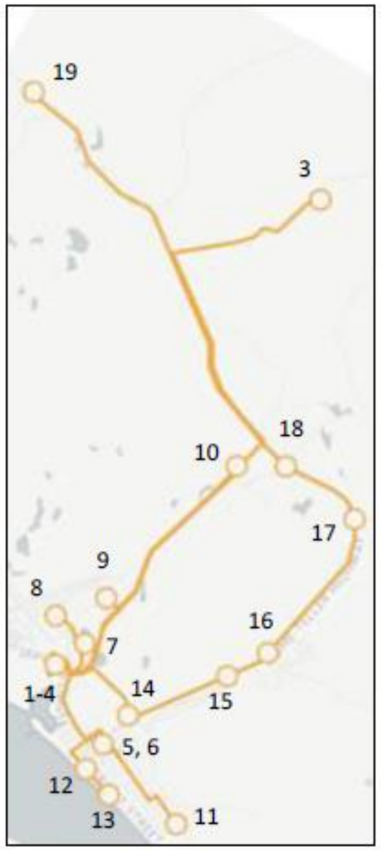


Networked Microgrids & Remote Systems

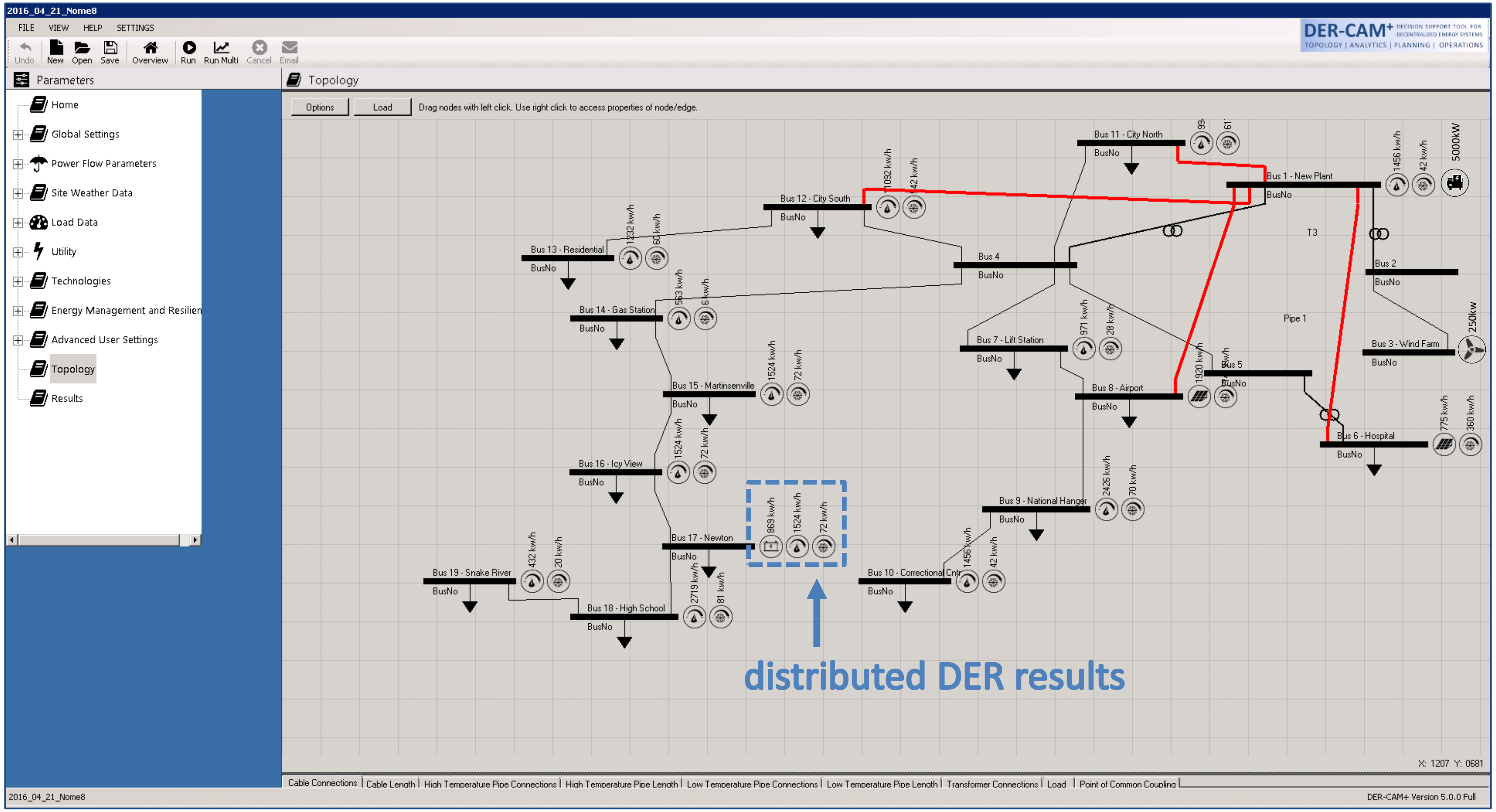
Case Study

- City of Nome in Alaska
- Isolated grid
- Radial 4.16 kV dist. network
- 19 nodes (in our model)





Networked Microgrids & Remote Systems

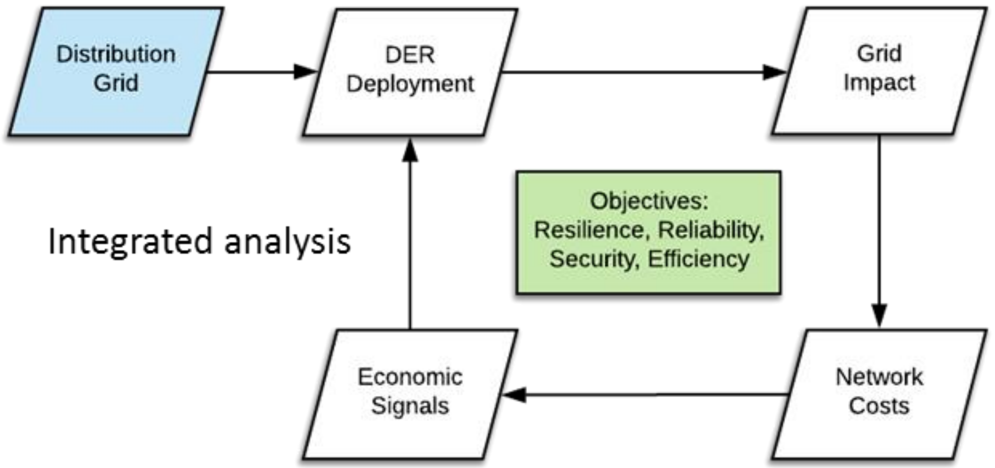


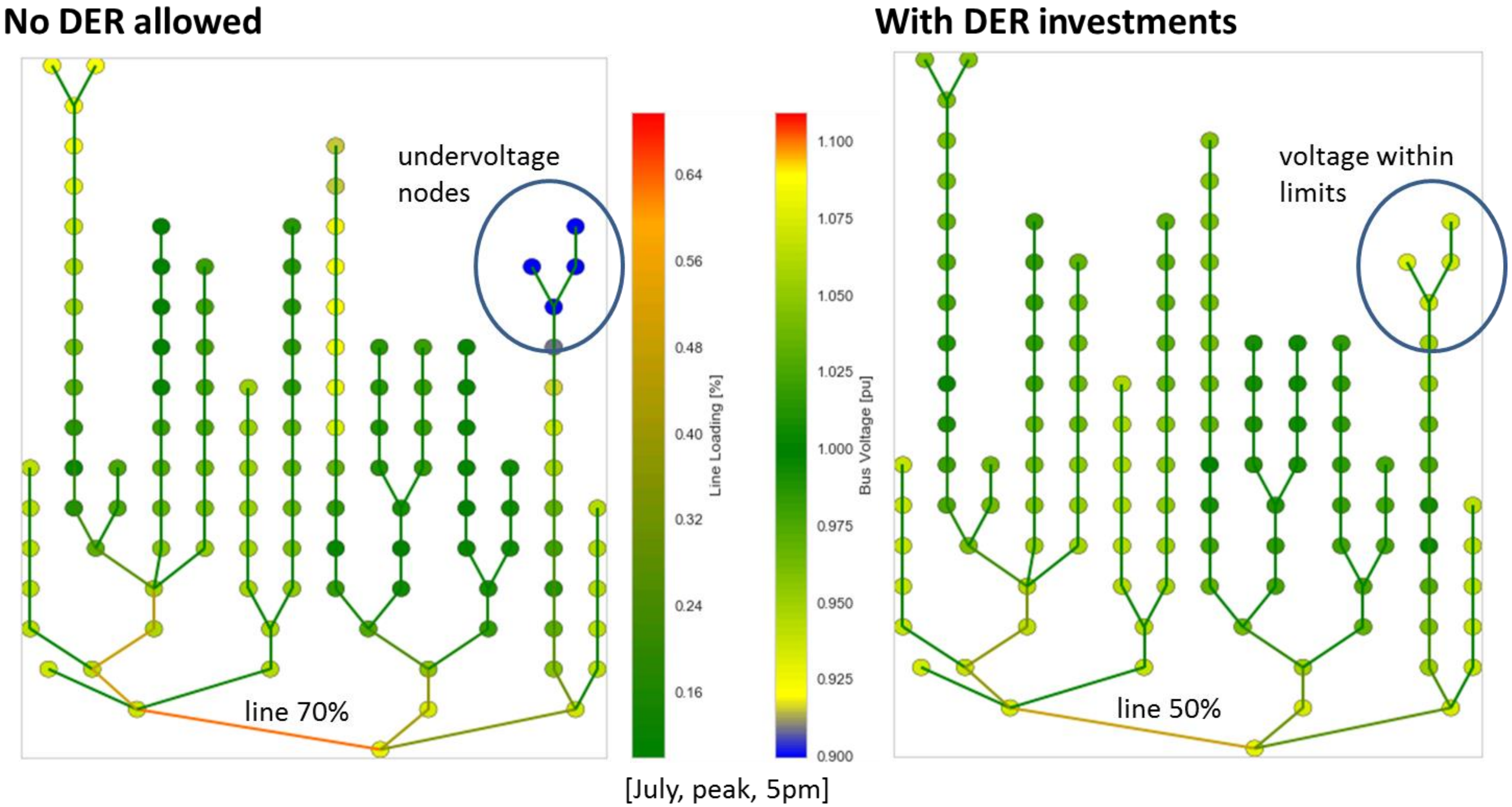
Aggregated Modeling of Grid Impacts

Estimate DER grid impacts through Integrated Modeling Tool

Develop new modeling tool to enable:

- Economic and technical assessment of behind-the-meter DER deployment
- Identifying ideal retail rate designs to enhance resilience, reliability, grid operation costs, power quality and security of supply through DER deployment
- Estimating favorable locations and hourly availability of DER assets to improve grid operations and promote DER participation in wholesale and reserve markets

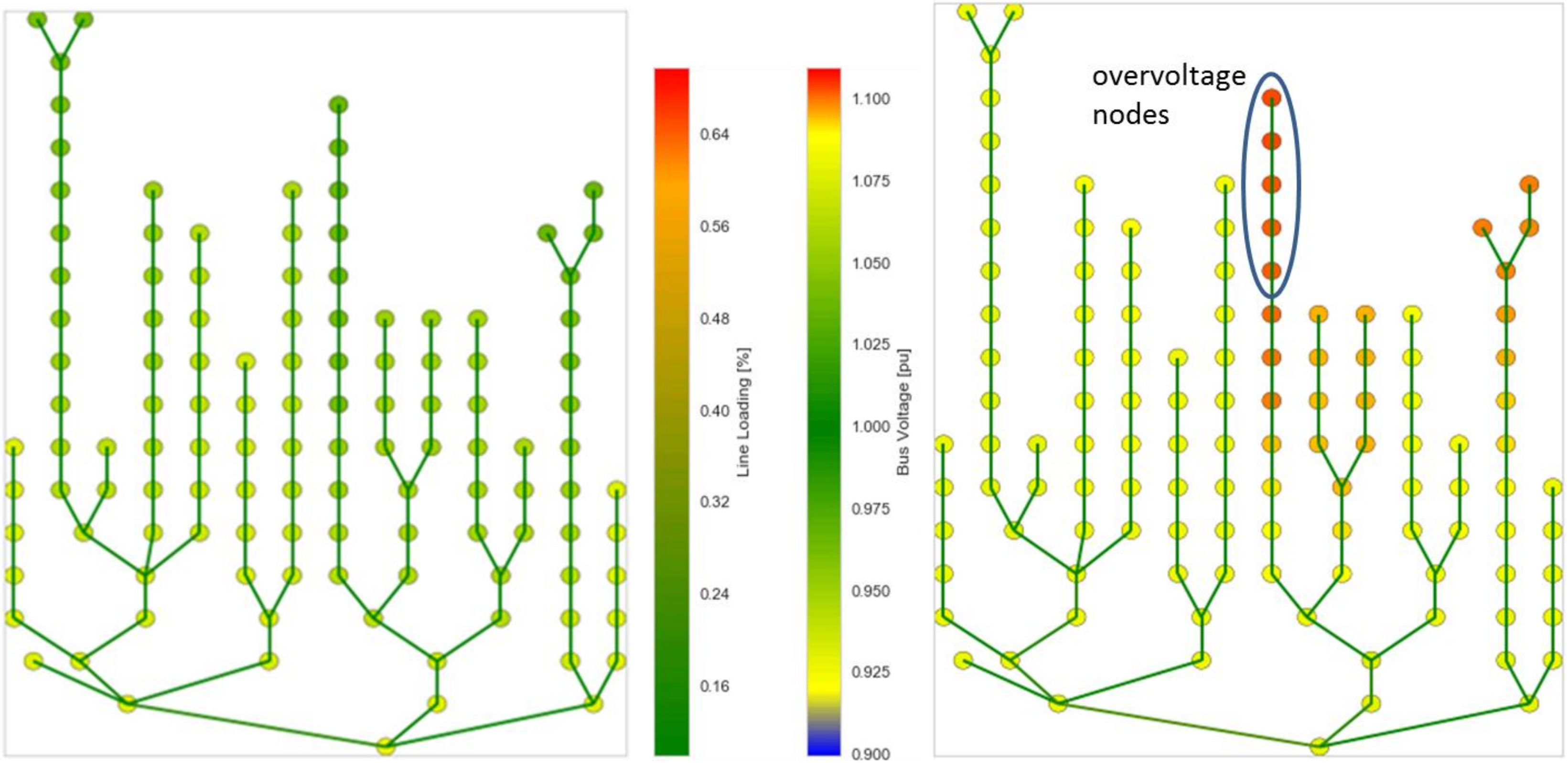




System-level visualization of grid impact on voltage levels, line loading

No DER allowed

With DER investments



[May, weekend, 12pm]

System-level visualization of grid impact on voltage levels, line loading

Planned Developments

- Simple DER-CAM API
- Data support for Energy Efficiency
- Automate scenario-based resiliency analysis
- Expanded ancillary service options

DER-CAM

BERKELEY LAB

learn more at:

dercam.lbl.gov

contact us at:

dercam@lbl.gov

+
Wrap-up and Takeaways