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NREL RESILIENCE ANALYSIS & PARTNERSHIPS WITH LOCAL GOVERNMENTS

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NATIONAL RENEWABLE ENERGY LABORATORY

National Renewable Energy Laboratory (NREL)

1,800

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

World-class
facilities, renowned technology experts

nearly 750

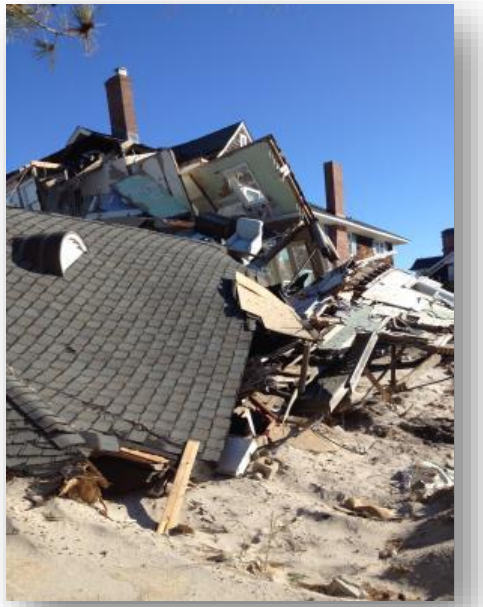
Partnerships
with industry, academia, and government

Campus
operates as a living laboratory

$872M annually

National economic impact

Disaster Recovery at NREL



- NREL's disaster recovery work has led to a deeper understanding of resilience and how it can be built into nearly every project at the laboratory.
  - Galena, AK
    - Replacing 6, inherited diesel generators with more efficient generators and a biomass plant after NREL's assessment of their energy system. They've also changed a substation and are replacing an overhead line to reduce transmission and distribution losses along their grid infrastructure.
  - New Jersey
    - Has been implementing NREL's recommendations through an Energy Resilience Bank which is funding alternative/RE technologies for critical infrastructure and assessment of facilities in the state.

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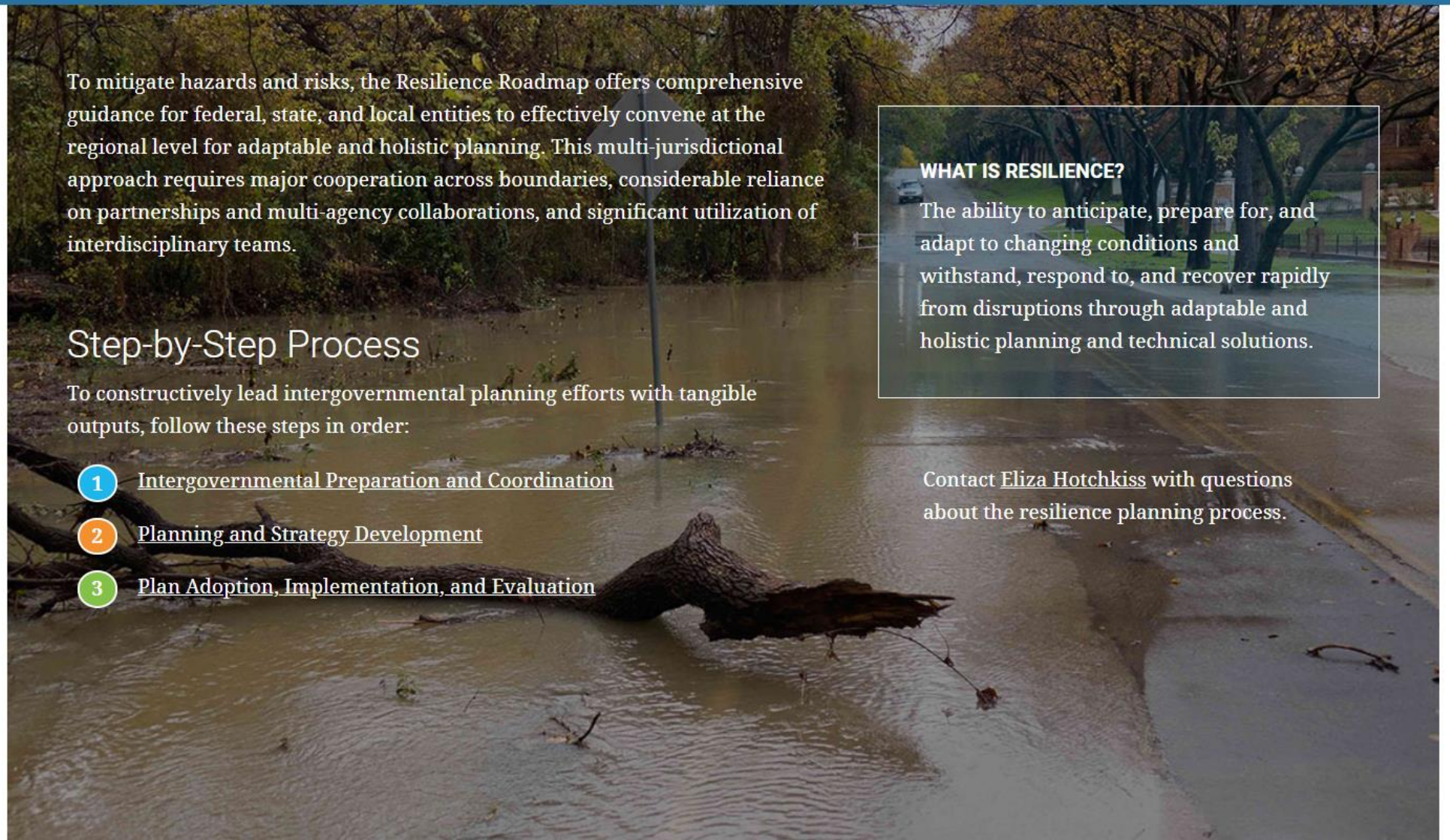
WHAT IS RESILIENCE?

"the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions".

Resilience Roadmap

A Collaborative Approach to Multi-Jurisdictional Planning



To mitigate hazards and risks, the Resilience Roadmap offers comprehensive guidance for federal, state, and local entities to effectively convene at the regional level for adaptable and holistic planning. This multi-jurisdictional approach requires major cooperation across boundaries, considerable reliance on partnerships and multi-agency collaborations, and significant utilization of interdisciplinary teams.

WHAT IS RESILIENCE?

The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions.

Step-by-Step Process

To constructively lead intergovernmental planning efforts with tangible outputs, follow these steps in order:

1. Intergovernmental Preparation and Coordination
2. Planning and Strategy Development
3. Plan Adoption, Implementation, and Evaluation

Contact Eliza Hotchkiss with questions about the resilience planning process.

Technical Resilience Navigator

Site-Level Planning

- Define initial scope
- Identify and engage stakeholders
- Collect and review relevant information
- Determine site-level critical missions and functions

Risk Assessment

- Identify hazards and threats
- Assess vulnerabilities
- Determine potential impacts
- Conduct gap analysis

Solution Prioritization

- Conduct qualitative evaluation
- Conduct quantitative evaluation
- Rank Solutions

Portfolio Planning

- Document existing policy requirements
- Identify or define portfolio critical missions and functions
- Identify or establish resilience goals

Baseline Development

- Collect data on baseline conditions and resource use
- Determine energy and water requirements
- Identify dependencies and interdependencies

Solution Development

- Assess operational improvements
- Assess institutional practices and procedures
- Identify technical solutions

Project Execution

- Identify funding streams
- Develop business case
- Execute projects

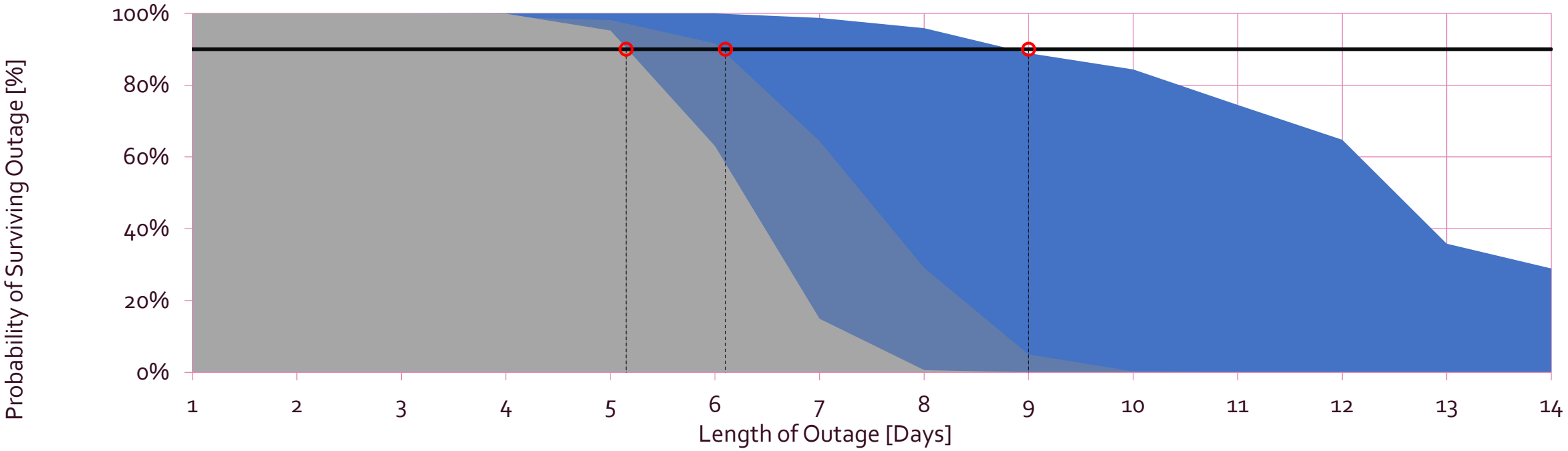
Resilience Assessment and Data Explorer (RADE)

To help with risk assessments, solution identification, and solution prioritization NREL is developing the RADE tool:

- Identify hazards and threats
- Assess vulnerabilities
- Determine potential impacts
- Identify technical solutions
- Rank solutions

Quantifying Resilience with REopt: Days of Survivability

	Generator	Solar PV	Storage	Lifecycle Cost	Outage
1. Base case	2.5 MW	-	-	$20 million	5 days
2. Lowest cost solution	2.5 MW	625 kW	175 kWh	$19.5 million	6 days
3. Proposed system	2.5 MW	2 MW	500 kWh	$20 million	9 days



K. Anderson et al., "Increasing Resiliency Through Renewable Energy Microgrids". SCTE Journal of Energy Management Vol.2 (2) August 2017 pp.22-38. https://www.nrel.gov/docs/fy17osti/69034.pdf

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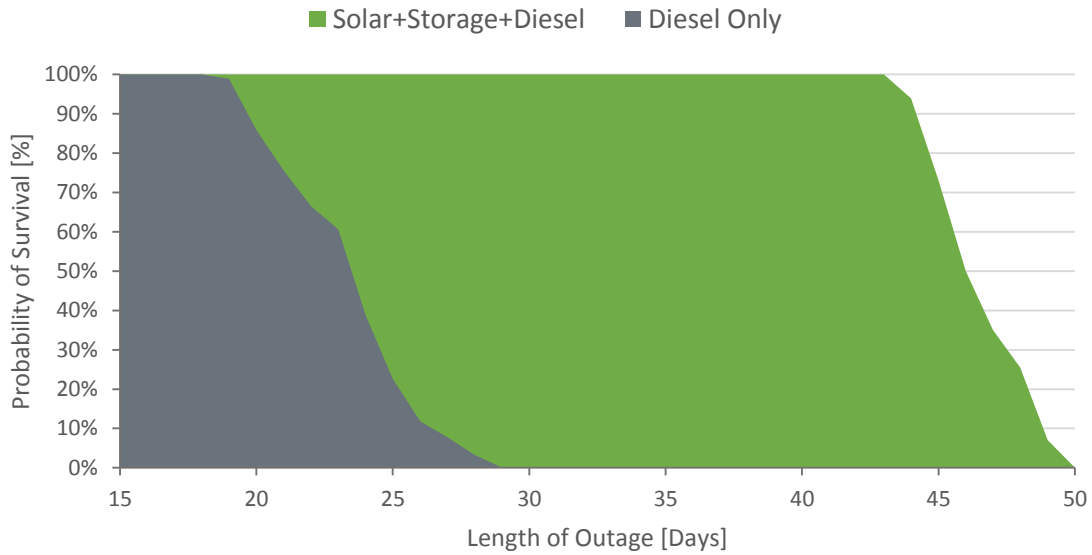
RESILIENT ENERGY SYSTEM ANALYSIS IN COASTAL NC

Analysis Overview

- NREL used the **REopt** tool for renewable energy integration and optimization to evaluate the techno-economic potential of adding **solar + storage** at four critical facilities:
  - Government Center
  - Radio Tower
  - Regional Airport
  - Water Treatment Plant

- Comparison of the probability of surviving outages of different durations with
  - a diesel generator and fixed fuel supply OR
  - a generator augmented with a PV and battery system



	Diesel-only	PV-Battery-Diesel Hybrid
PV size	–	33 kW
Battery size	–	5 kWh
Inverter size	–	10 kW
Generator size	40 kW	40 kW
Available fuel	200 gallons	200 gallons

Resilience Scenario Results for Radio Tower

PV Installation Economical

Summary Results for Certain PV Systems by Facility					
	Barco Radio Tower	**Cape Hatteras Water Treatment Plant (full site)**	**Cape Hatteras Water Treatment Plant (RO #4)**	**Currituck County Regional Airport**	**Hyde County Government Center**
PV size (kW)	28.66	361.95	76.20	34	50
Battery size (kWh)	0	0	0	0	0
Existing Generator Size (kW)	40	1530	100	0	135
Net present value ($)	$13,421	$201,540	$54,038	$11,720	$38,380
Life-cycle savings (%)	16.3%	4.3%	1.2%	12.3%	2.0%

- Deploying PV is economical at all four critical facilities, providing electricity bill savings during normal operation.
- When available, participation in net metering programs improves the net present value of PV, resulting in larger optimal PV sizes.

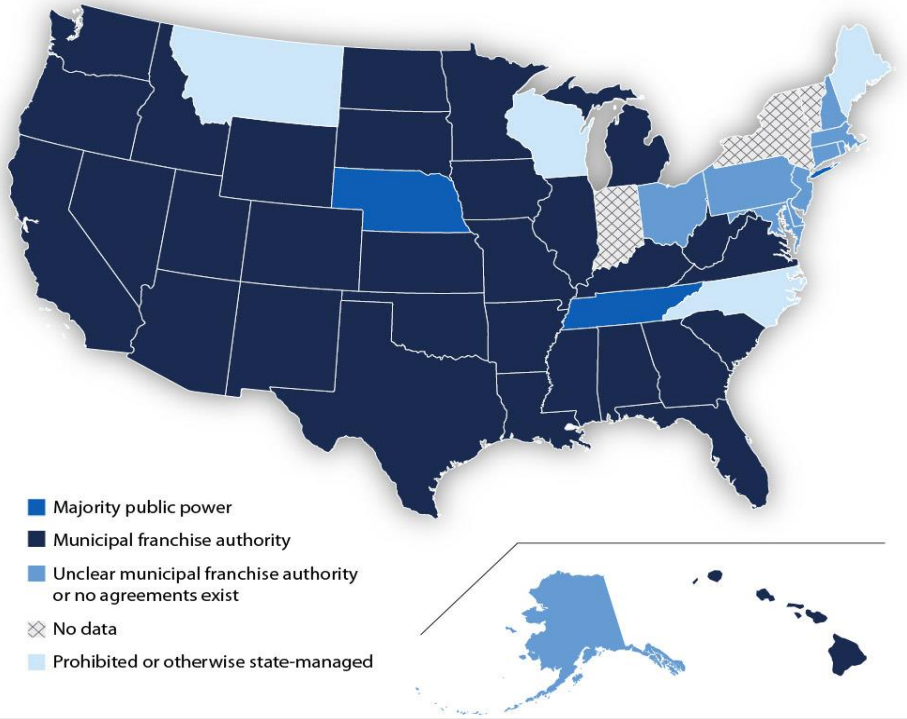
PV + Storage has resilience, but not direct economic benefits

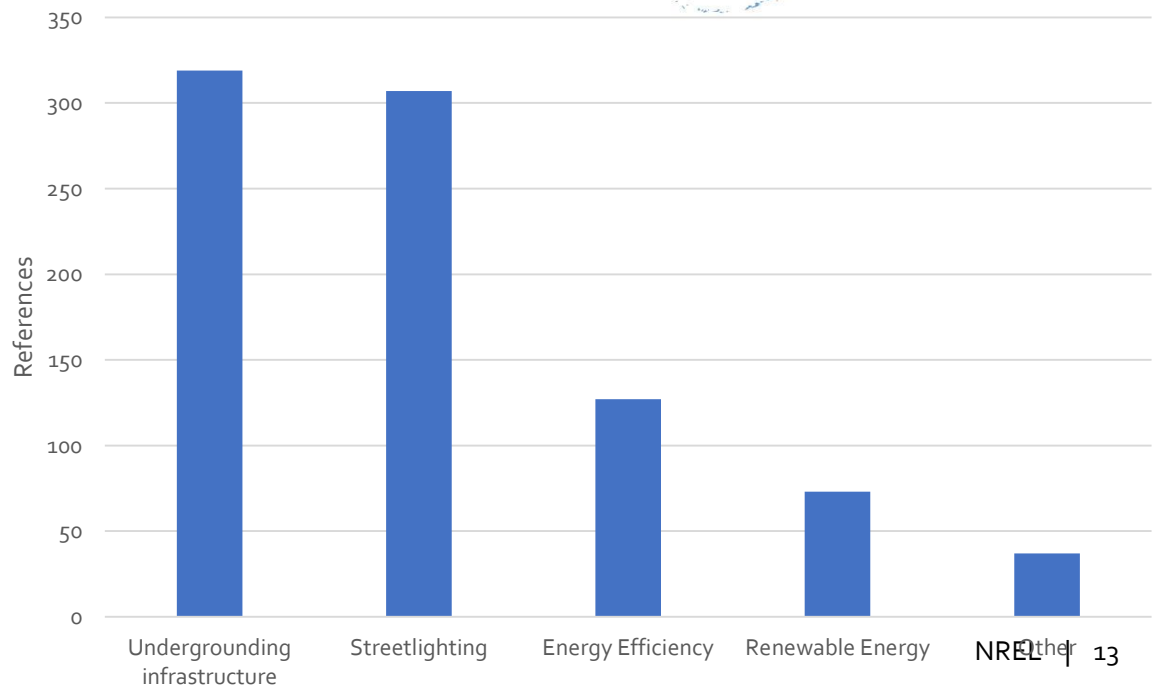
Summary Results for Certain Resilient PV Systems by Facility

	Barco Radio Tower	Cape Hatteras Water Treatment Plant (full site)	Cape Hatteras Water Treatment Plant (RO #4)	Currituck County Regional Airport	Hyde County Government Center
PV size (kW)	32.66	418.67	84.48	37	50
Battery size (kWh)	5	180	25	5	25
Inverter size (kW)	10	360	50	10	50
Generator Size (kW)	40	1530	100	20	135
Net present value ($)	$366	-$249,550	-$7,307	-$31,472	-$30,970
Life-cycle savings (%)	0.4%	-5.3%	-0.2%	-33%	-1.6%
Extended Operation (days)	25	Not assessed	0.25	7.6	0.54

Financing Considerations

- Public-private partnerships
  - Partnerships with federal and private sector facilities
- Grant funding
  - FEMA hazard mitigation grants
- **Municipal franchise funding**
- Bond funding
  - Resilience bonds





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THANK YOU!

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