Planning an Affordable, Resilient, and Sustainable Grid in North Carolina

U.S. Department of Energy

North Carolina Department of Environmental Quality

Energy Production & Infrastructure Center (EPIC),
University of North Carolina at Charlotte

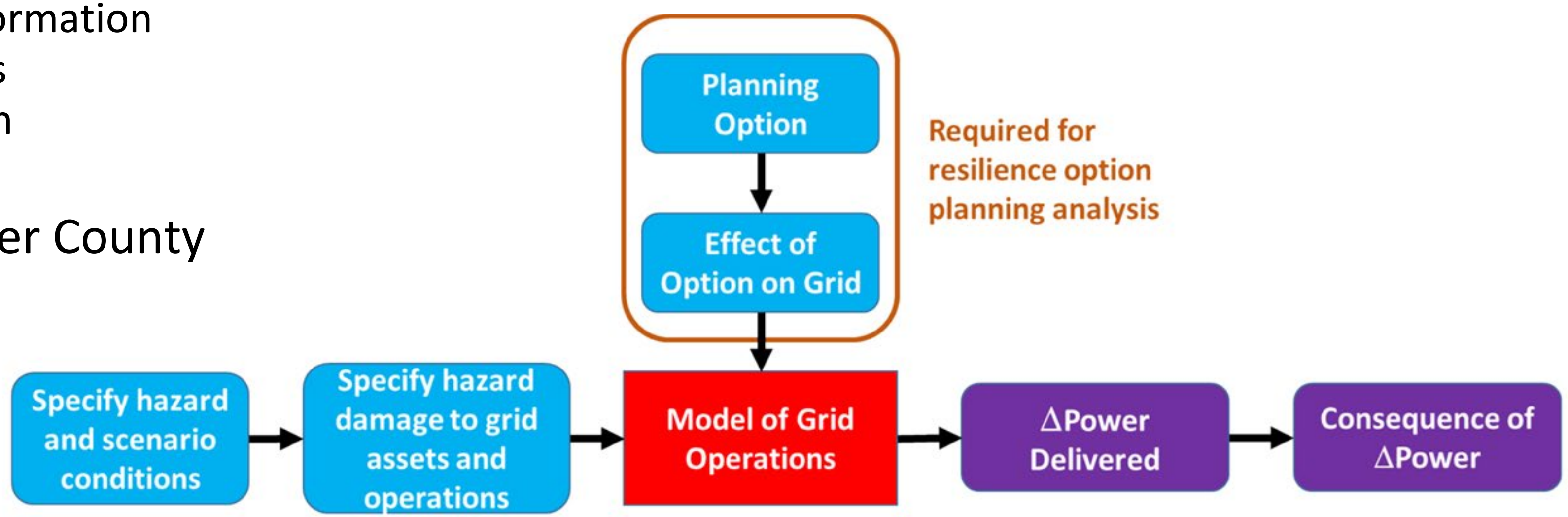
NC Clean Energy Technology Center (NCCETC),
NC State University

Project Context

- Challenges in North Carolina:
  - Duke Energy Power Forward Proposal in 2017
- Meeting the challenge:
  - NCDEQ 2019 Clean Energy Plan, 2020 Climate Risk Assessment & Resilience Plan developed under EO80
  - NARUC, NASEO,U.S. DOE Comprehensive Electricity Planning Task Force (through Feb 2021)
  - 2019 Duke Energy (DE) rate cases containing the Grid Improvement Plan
  - Duke Energy Climate Resilience Study
  - Duke Energy Integrated System & Operations Planning (ISOP)
- U.S. Dept. of Energy, State Energy Program Competitive Award
  - Project began in 2019

Project Approach

- Scenario 1: What have been the consequences of weather-related power outages in North Carolina?
- Scenario 2: What is the value and need for infrastructure hardening?
- Scenario 3: What is the value and need for advanced solutions (i.e. microgrids & resilient backup power)?
- Duke Energy has actively provided data
  - 10 years of outage information
  - Detailed circuit models
  - Grid Improvement Plan
  - Expert interpretation
- Focused on New Hanover County



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Key Findings

- ***Finding #1:*** Need for greater stakeholder education on outage impacts in North Carolina:
  - We're not all operating from the same set of assumptions!
- ***Finding #2:*** Need for greater engagement between local governments & utility partners
- ***Finding #3:*** Need for new metrics that recognize the shared need for hardening & DERs:
  - Must value the necessity of hardening to enable greater penetration of DERs
  - Must find a way to rate-base and/or cost-share resilient back-up power, considering the full stacked benefits

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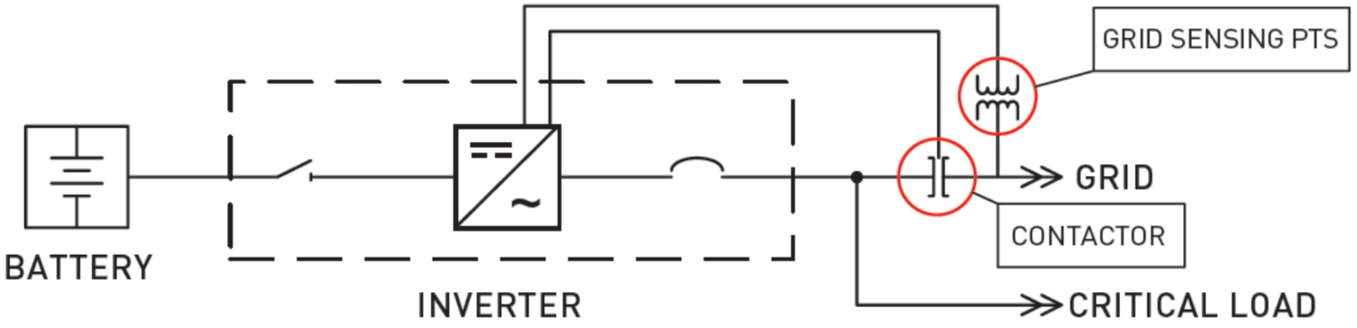
Microgrids vs. Resilient Back-Up Power



- Microgrid: A group of inter-connected loads and DERs within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. Can connect and disconnect from the grid, operating either grid-connected or islanded.
  - Backup systems with diesel generators can fit this description
- In this work:
  - Microgrid: A collection of facilities (possibly a whole feeder) that can disconnect from the grid
  - Resilient back-up power: A means of providing backup power to a building or buildings that provides resilience against fuel disruption

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Resilience is Contextual

		Questions to consider
Who?		Who determines what is desirable for an urban system? Whose resilience is prioritized? Who is included (and excluded) from the urban system?
What?	T R A	What perturbations should the urban system be resilient to? What networks and sectors are included in the urban system? Is the focus on generic or specific resilience?
When?	D E O	Is the focus on rapid-onset disturbances or slow-onset changes? Is the focus on short-term resilience or long-term resilience? Is the focus on the resilience of present or future generations?
Where?	F F S	Where are the spatial boundaries of the urban system? Is the resilience of some areas prioritized over others? Does building resilience in some areas affect resilience elsewhere?
Why?		What is the goal of building urban resilience? What are the underlying motivations for building urban resilience? Is the focus on process or outcome?

Note: Adapted from Meerow et al. (2016).

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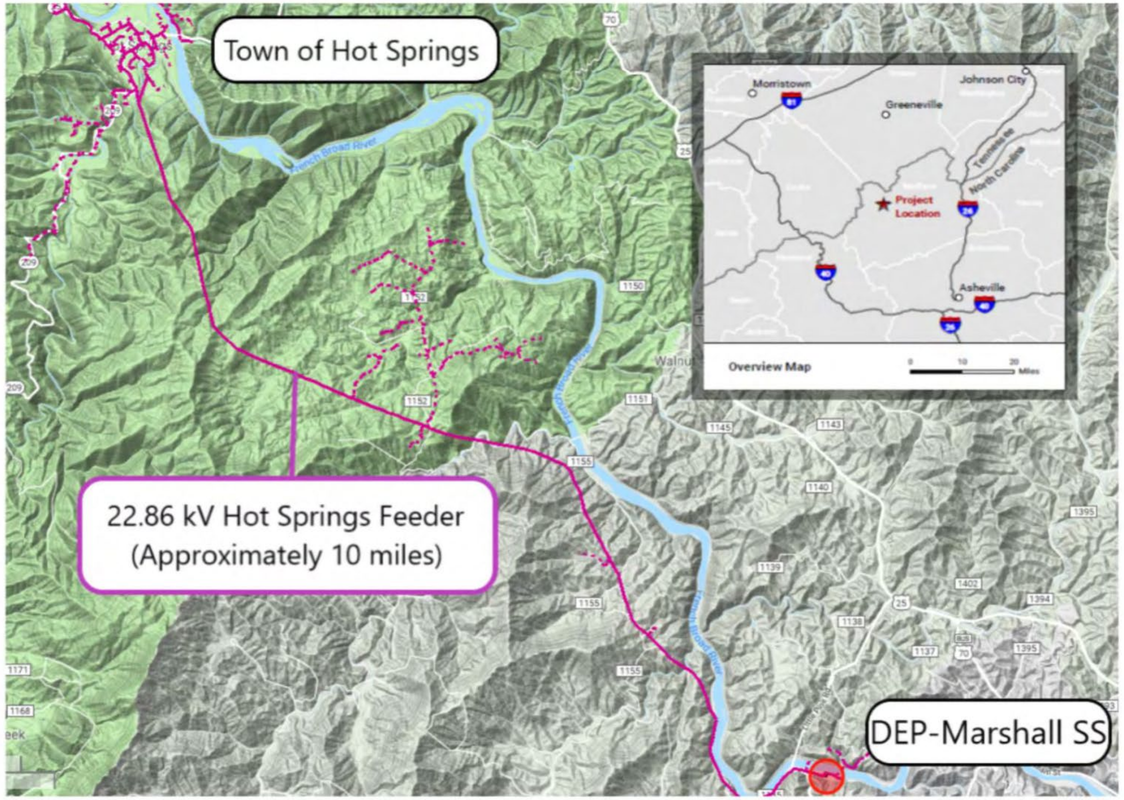
Common Outage Scenarios in North Carolina

- Outage Type 1: Loss of power from a single upstream location (possibly transmission)
  - Wildfire-prevention outage
  - Texas outages
  - Hot Springs / Ocracoke Island
- Microgrid is an excellent technical solution
  - Whether it is lowest cost is up for debate



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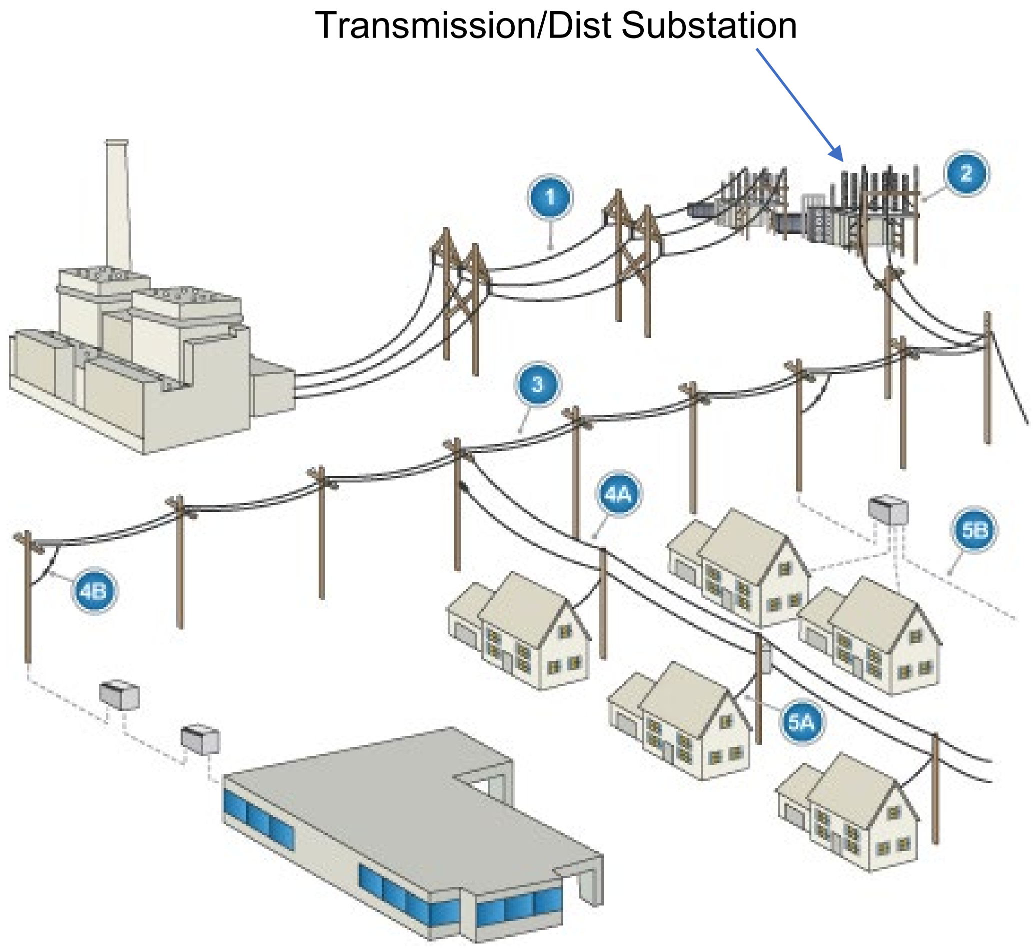
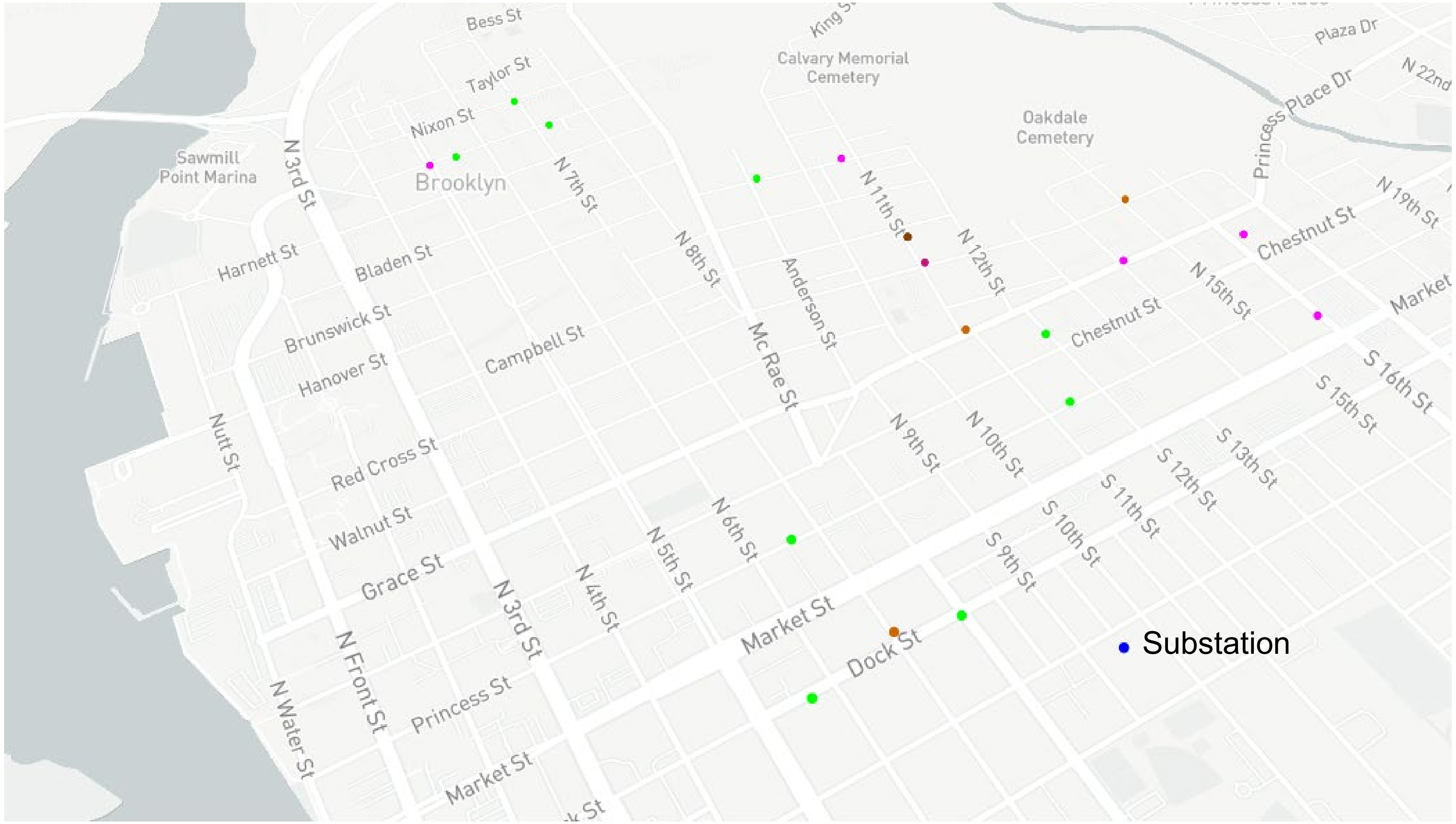
Outage Type 2: Widespread Outages Throughout a Distribution System

- Multiple 23kV lines moving radially outward from the substation (typical)
- Lines branch off from the main feeder line
- Feeder breakers
- Reclosers
- Sectionalizers
- Line fuses
- Transformer fuses



Typical Distribution Outages in A "Minor" Major Event

- Feeder Breaker
- Line recloser
- Line fuse
- Transformer fuse
- HPP Breaker / Meter Base
- Disconnect
- Jumper wire cut
- Sectionalizer



Typical Distribution Outages in A "Minor" Major Event

Line Fuse Events

Customers Impacted	Duration (hours)
12	45
33	58
11	74

Line Recloser Events

Customers Impacted	Duration (hours)
458	9.72
619	21
161	5.9

Line Breaker Events

Customers Impacted	Duration (hours)
All	1.7

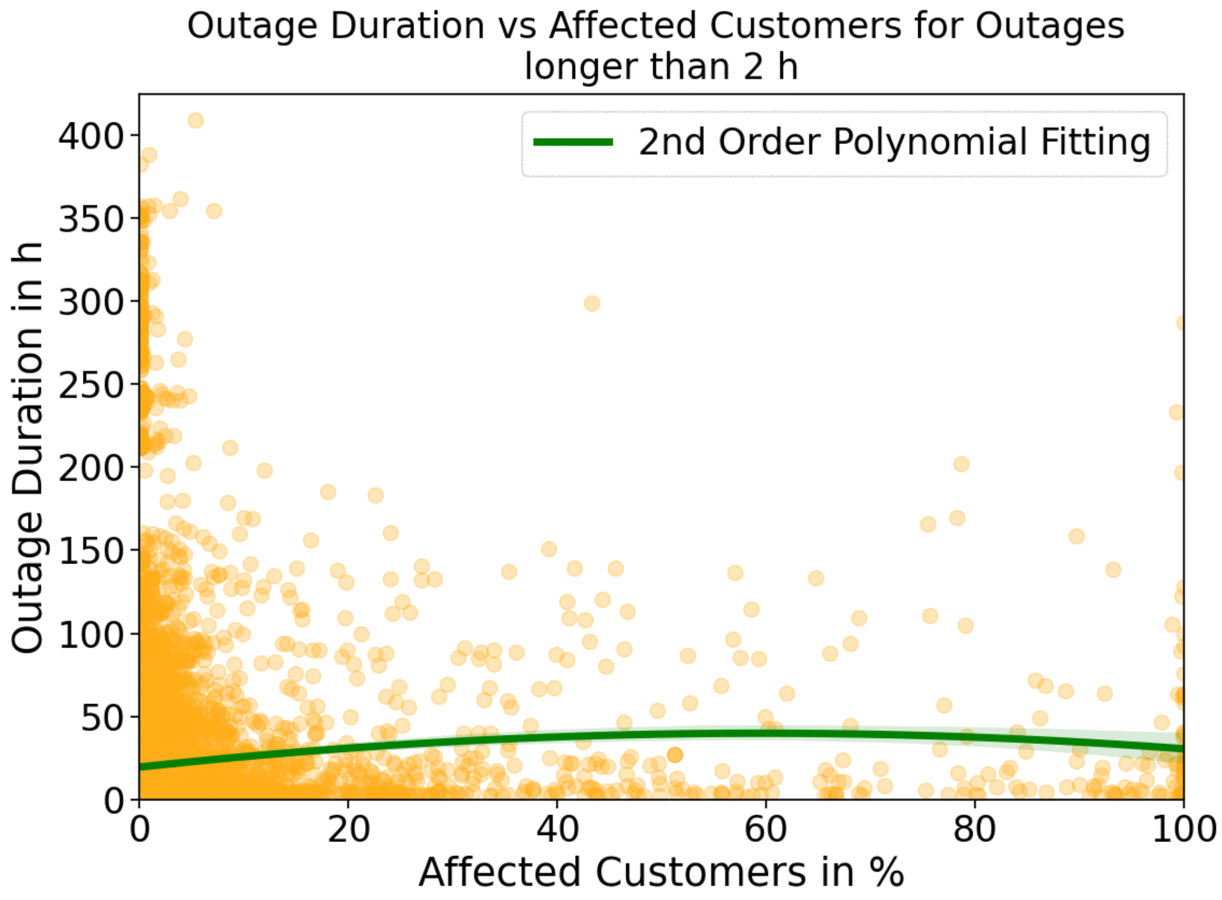
Transformer Fuse Events

Customers Impacted	Duration (hours)
7	76.8
16	36.6
9	18.59
5	18.07
11	5.35
16	0.45

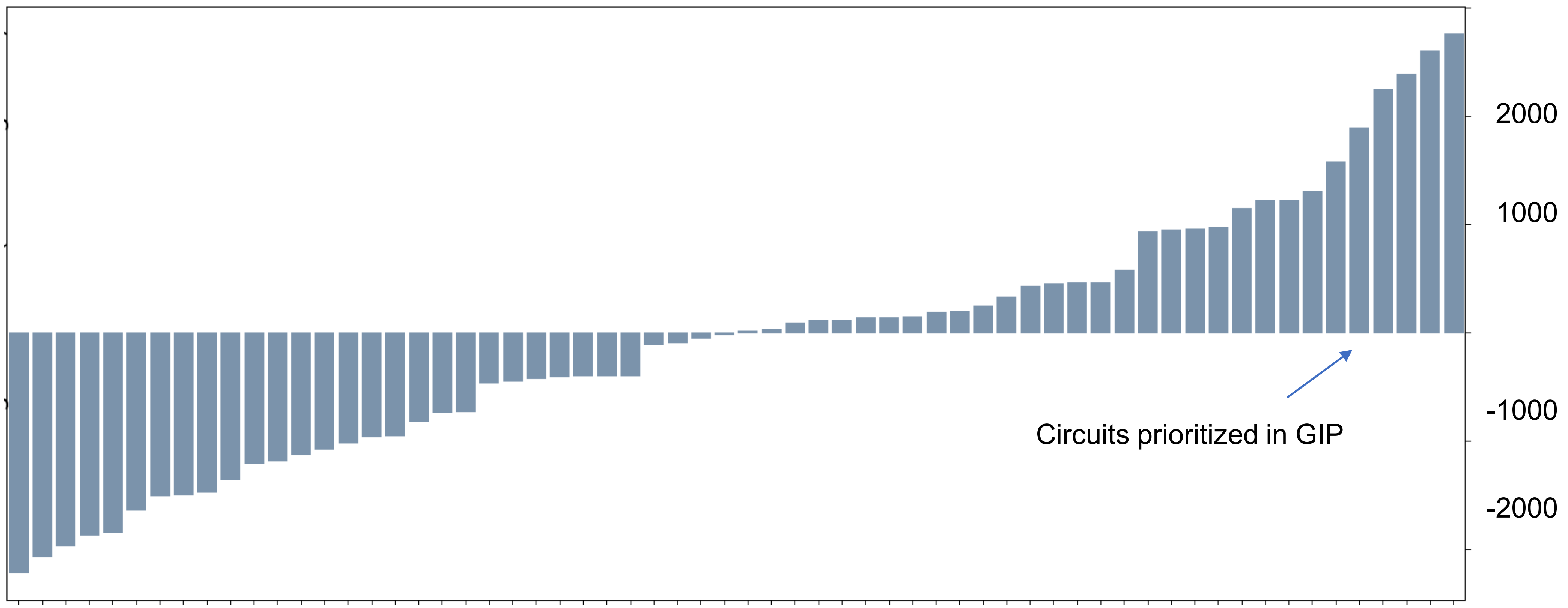
11 customers with individual outage records

Typical Distribution Outages in A "Minor" Major Event

- The largest number of outages affect a small number of customers on the distribution feeder
- Microgrids are not a clear solution in this scenario



Distribution of Customer Outage Minutes Relative to Median for NHC (No MEDs)



Assessing Vulnerability

- Assessing ***specific*** vulnerability of the distribution system is extremely challenging
  - Amount of previous rainfall before a storm can impact soil conditions and tree vulnerability
  - Trees outside of right-of-way cause many of the outages
- Assessing vulnerability for substations is somewhat more straightforward:
  - Examine flood conditions
- NHC transmission-to-distribution substations did not flood in Florence or Matthew
- NHC generation-to-transmission substations were hardened
- Our analysis considers vulnerability under SLOSH-MOM analysis
  - Ensemble of possible storm-surge scenarios

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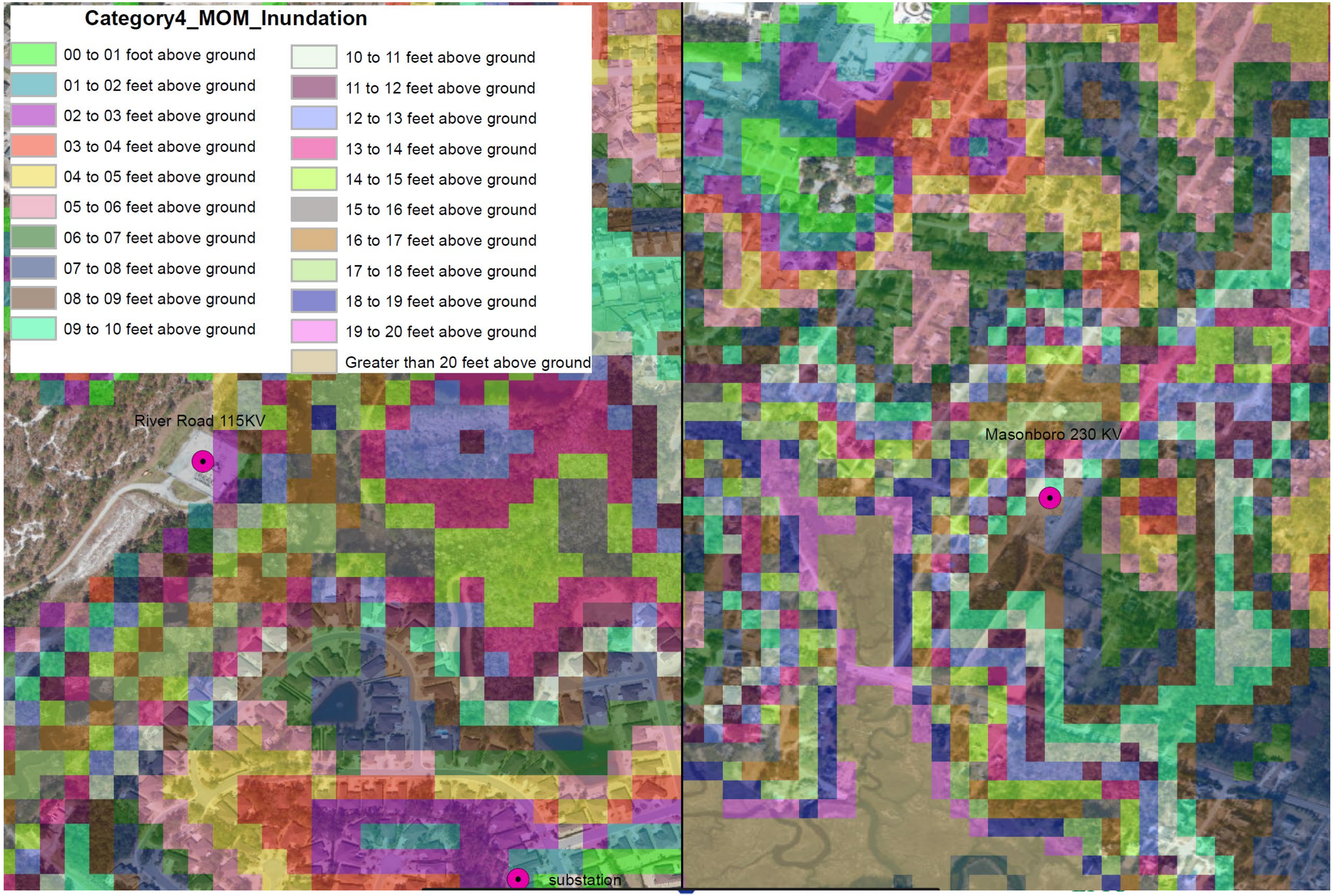
Substation Examples: CAT 2 Storm Surge

Substation Examples: CAT 4 Storm Surge



Enabling DERs Likely Requires Both Traditional Hardening

- Enablement of DERs for resilience requires a hardened grid
- Lowest cost solutions to ensuring greater resilience likely combine DERs & hardening
  - Lowest cost solutions need to factor in
    - Potential loss of critical infrastructure
    - Potential loss of community function
- This requires a better understanding of community consequences and costs
  - This could be factored into performance-based metrics
- More on community costs in second session

What is The Community's Response to Major Events?

- Hurricane Florence:
  - Every major access route closed due to flooding
    - No access to diesel fuel from outside of county
  - CFPUA: Fuel needed to be pumped from the port to provide diesel for back-up generators
  - 5.25 million gallons of partially treated sewage released due to generator flooding at Southside Wastewater Treatment Plant

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What is The Community's Response to Major Events?

- FEMA provides a unified framework for considering the benefits of improved resilience
- Had the water plant been lost:

% of County Impacted	FEMA standard value
25	$5.25MM/day
50	$10.5MM/day

Loss of service type	FEMA standard value
Electric power	$148/person/day
Potable water	$105/person/day
Wastewater	$49/person/day

$$\frac{\text{Benefits}}{\text{Costs}} = \text{BCR}$$

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What is The Community's Response to Major Events?

- CBO: Total recovery cost for community is perhaps 50x the utility recovery cost
- Disaster spending in affected counties tends to be $155 to $180 per capita (T. Deryugina, 2017)
  - Does not include NGO funds
  - Does not reflect staffing costs

What is The Community's Response to Major Events?

- Community also has significant staffing costs

Categories	Challenges
Communication	• Traditional / social media did not reach most impacted
Sheltering / Displacement	• Large % need shelter
Commodity Distribution	• Large, centralized POD underutilized • High need pop. underserved
Food Loss	• 100% households experienced food loss
Mass Feeding	• Multiple organizations / efforts • 2-3 meals / day for 28 days

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Key Recommendation: Community-Utility Engagement

- Utilities focus on restoration:
  - Develop critical infrastructure priorities based on lists given by local government
  - Restore power from substation working outward
- Local governments focus on feeding, sheltering, safety, etc.
- ***The two parties do not currently coordinate around improvement priorities in advance***
- Process:
  - Establish procedure for soliciting resilience priorities from local stakeholders
  - Establish transparency about how distribution upgrades can be targeted to address resilience priorities
- Examples of the disconnect:
  - Undergrounding in New Hanover County

Discussion in First Breakout Session

- How can we improve the dialogue between communities and utilities?
  - What ***specific*** data is really needed?
    - Example: SAIDI on a circuit-by-circuit basis?
  - How can utilities better determine the needs of a community in advance of a storm? What processes should be considered? How can the process be data-driven and informed?
  - How can utilities better engage in more rural areas where local governments do not have as many resources to engage in planning?

Next Session

- Paying for resilient back-up power
  - Analysis for 8 sites by NCCETC team
- How do we factor in community costs and move to a better model?

Part II Factoring in Community Costs

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Rate-Basing Costs?

- Example from Christina's analysis:
  - 7 days of resilience at NWWTP with $3.385MM (1.4MW of guaranteed capacity)
  - $2,299 per kW
- National average: $940 per kW for peaking power from NG
- Duke has programs that pay for back-up generation
- Could utility pay for backup power solutions?
- What are the other benefits?

Factoring in Community Costs

- Example from Christina's analysis:
  - 7 days of resilience at NWWTP with $3.385M
- 50% of county loses wastewater:
  - $34M for 7 days
- 25% of county loses wastewater:
  - $17.1M for 7 days

% of County Impacted	FEMA standard value
25	$2.45MM/day
50	$4.9MM/day

Loss of service type	FEMA standard value
Electric power	$148/person/day
Potable water	$105/person/day
Wastewater	$49/person/day

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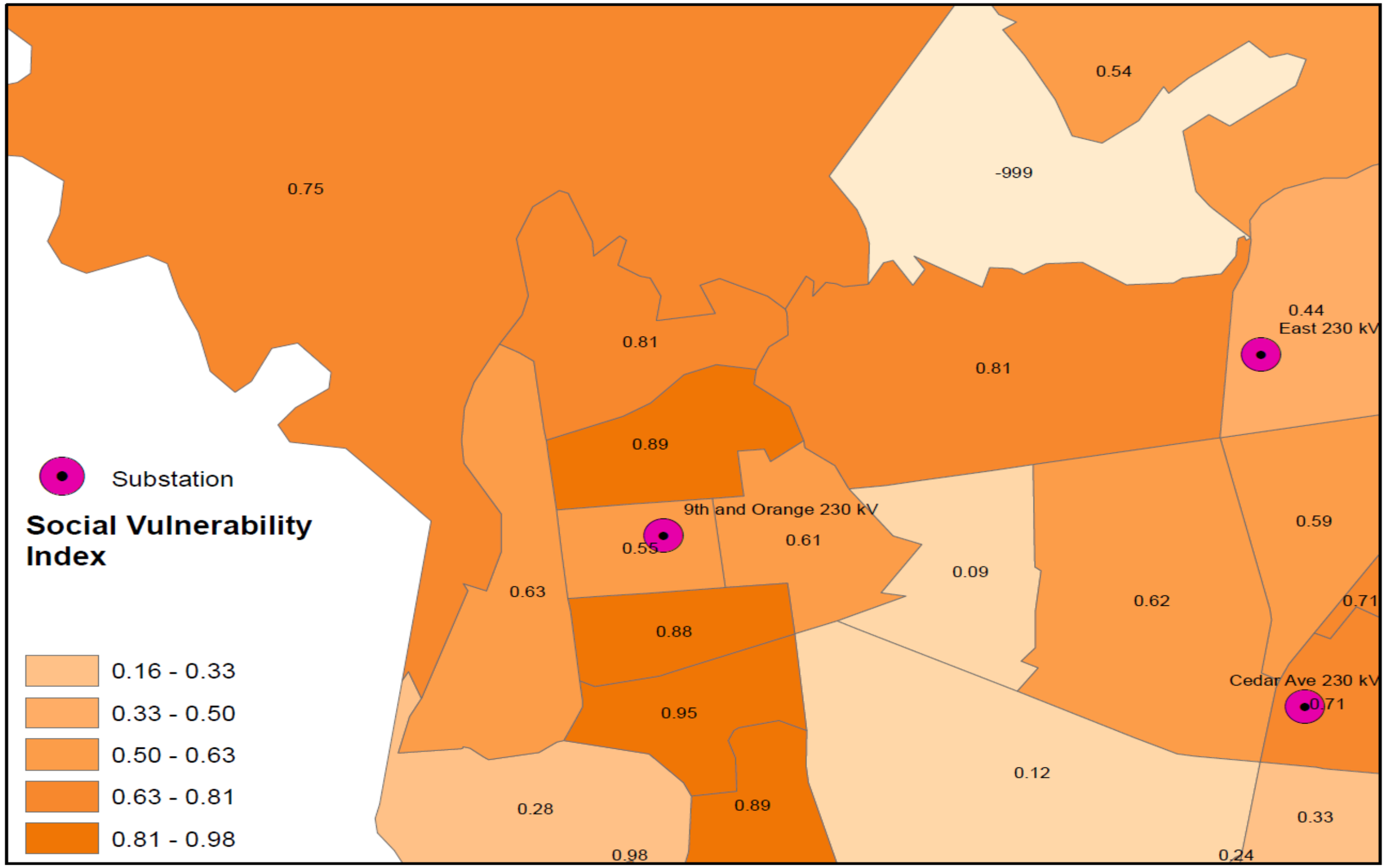
Example: Northside Neighborhood

- Social Vulnerability Index (SVI): 15 factors
- Four themes:
  - Socioeconomic status
  - Household composition
  - Race/ethnicity/language
  - Housing/Transportation
- Northside neighborhood:
  - Pockets of customers without power for ~2 weeks



Example: Community Outpost

- Two basic costs that could be considered:
  - Food contents damaged (D-SNAP) benefits
  - Sheltering costs
- Assumptions:
  - Outpost can protect 100 customers with an average family of 4
  - Outpost can provide ice
  - Outpost can keep residents in homes

Categories	Challenges
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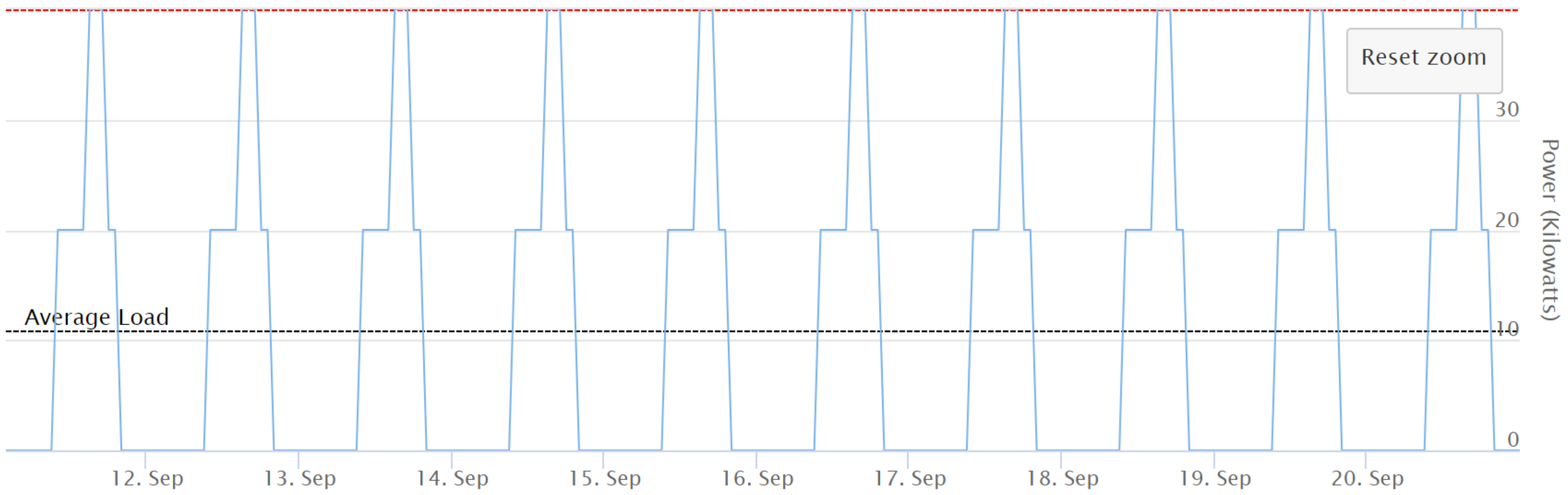
Example: Community Outpost in Northside Neighborhood

- Power reaches to 40kW from 3 to 6 for commercial kitchen
- System:
  - 76kWdc PV
  - 440kWh/40kW battery
- $340k capital cost



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Example: Community Outpost in Northside Neighborhood

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  - 440kWh/40kW battery
- $340k capital cost

Categories	Enables
Communication	• Ability to message to community • Ability to allow cell phone charging
Sheltering / Displacement	• Allows community to remain in homes
Commodity Distribution	• Better serves the high-need population • Could also reduce POD costs
Food Loss	• Allows homeowners to maintain foodstuffs
Mass Feeding	• Allows homeowners to possibly cook their own food

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Example Benefits: 2-Week Usage

- Food damage:
  - D-SNAP for family of 4 in Florence $640
  - $64,000
- Sheltering cost:
  - Assume GSA rate: $119 per night per family
  - $11,900 per day for 2 weeks
  - $166,600
- Assuming families can cook their own food at outpost:
  - Assume GSA rate: $61 per day per person
  - $2,440 per day
  - $341,600
- $572,200 in quantifiable benefits; does not include administrative cost reductions

Example Benefits: 2 Days, 1x Per Year

- Food damage:
  - D-SNAP for family of 4 in Florence $640
  - $64,000 per event
- Sheltering cost:
  - Assume GSA rate: $119 per night per family
  - $11,900 per day
  - $23,800 per event
- Assuming families can cook their own food at outpost:
  - Assume GSA rate: $61 per day per person
  - $2,440 per day
  - $4,880 per event
- cost reductions
- Annual benefits: $92,680
- 20-year benefits: $1.85MM

Finding #3: Valuing Solutions

- Distributed energy resources with storage provide an alternative to natural-gas plants
  - Develop resilient back-up power solutions at a collection of locations throughout the state
  - Recognize the value of these facilities to provide guaranteed capacity and grid services
  - Recognize the value of these facilities to improve restoration efficiency by government
  - Develop models that allow rate-basing and cost-sharing of resilient power
- Value distribution hardening from the perspective of its ***necessity*** to enable DERs
  - If hardening & DERs could be combined on the circuit we considered previously, community costs could possibly be lowered even further
  - Utility & community could try to cost-share a solution

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Breakout Session Questions

- Does it seem reasonable to rate-base resilient back-up power solutions if they can provide key grid services?
- Should the utility commission require input from a community when evaluating a set of grid upgrades?   How should this input be integrated into the regulatory proceeding process?
- How should the utility commission consider non-least-cost solutions for providing resilient back-up power if the solutions also provide post-disaster benefits?

Next Steps

- Full report made available ~ January 2022
- Please send any follow-up questions to ckopito@ncsu.edu in the next two weeks
- Follow-up session for questions & feedback will be held later in October

Contacts & Info

Thank you for attending

More Info and Updates are available at:

PARSG Site

Star Hodge,
NCDEQ State Energy Program,
Star.Hodge@ncdenr.gov

Rob Cox,
UNCC EPIC,
robert.cox@uncc.edu

Christina Kopitopoulou,
NCCETC,
ckopito@ncsu.edu

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