Critical Infrastructure Resilience Technical Assistance - Navel Station Norfolk (NSN) 2020 Microgrid R&D Program Peer Review Meeting

PRESENTED BY

Robert Broderick, Bobby Jeffers & Amanda Wachtel

June 10, 2020

Critical Infrastructure Resilience Technical Assistance Navel Station Norfolk

Objectives & Outcomes

The objective of the project is to assist DOE and DOD to plan for and coordinate activities in the area Microgrid Feasibility. Specifically, we will be focused on implementing a holistic approach to improving resilience through consequence focused system analysis and design of electric power distribution systems.

The defense energy work will be focused on improving energy resilience of NSN both inside the base perimeter and outside the perimeter working with the local utility Dominion and other infrastructure utilities such as water.

Flood Inundation - (FEMA 100yr Flood with 3 ft. of Sea Level Rise)

Technical Scope

NSN:

1. Work will clearly map resilience metrics that support mission readiness and the placement and specification of resilience nodes.
2. SNL will be utilizing and validating multi-objective optimization techniques, including the Microgrid Design Toolkit, to formulate a more detailed system design for at least two resilience nodes.
3. Make recommendations to key stakeholders.

In Pittsburgh, SNL and project partners are validating the use of DER-CAM and ReNCAT to support integrated electrical and thermal planning including community resilience goals.
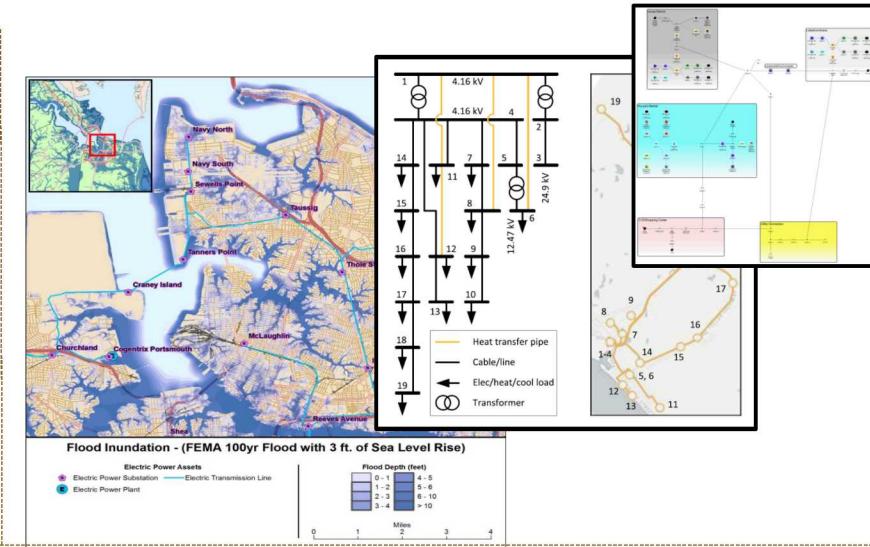
Funding Summary ($K)

FY19 & prior, authorized	FY20, authorized	FY21, requested
$1,000K	$ 500K	TBD

Problem Statement

Challenge:

The **critical need** is holistic planning that accounts for the resilience goals of DOD facilities, the opportunities/constraints of utilities, and emerging microgrid technology.

This includes a need to:

Determine benefits of microgrids to resilience, sustainability, and efficiency

Consider grid resilience's impact on DOD facility resilience

Consider regulatory hurdles, standardization of approaches, and other barriers to adoption

Significance

Innovation:

Developing and validating a holistic approach to improving resilience through consequence focused system analysis and design of electric power distribution systems that integrates the needs of DOD facilities and utilities.

Measuring and modeling resilience as the impact to DOD facilities, not just the impact to the grid.

Impact:

Showcasing first in practice microgrid designs (e.g. Pittsburgh and Norfolk)

Connecting and leading with other federal and international efforts:
- DoD community of practice around Energy Master Planning
- GMLC Metrics, GMLC RDS Designing Resilient Communities
- DOE response in Puerto Rico
- International Energy Agency Annex 73
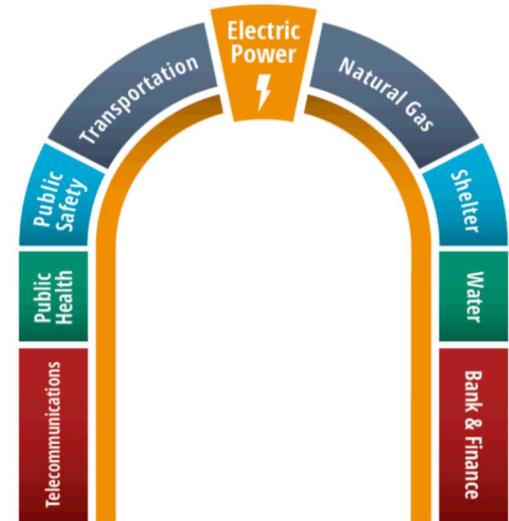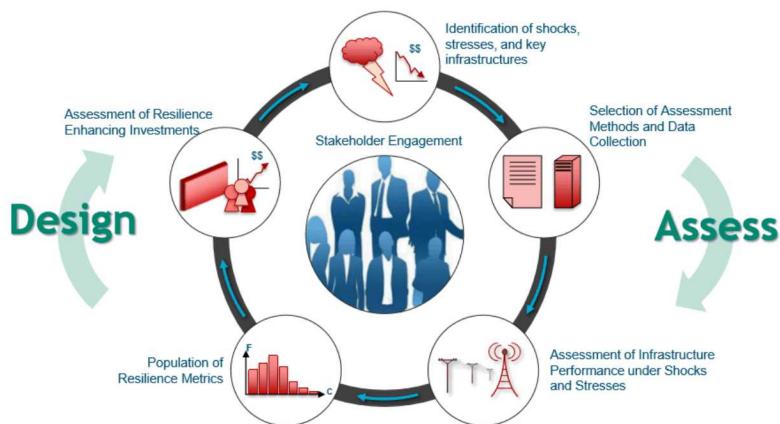
Norfolk Resiliency Project
Project Overview

Microgrid Feasibility of defense energy site Norfolk and Naval Station Norfolk (NSN)

OBJECTIVES

- The goal of the project will be to help DOE and DOD to plan for and coordinate activities in the area Microgrid Feasibility. Specifically, we will be focused on implementing a holistic approach to improving resilience through consequence focused system analysis and design of electric power distribution systems.

- The defense energy work will be focused on improving energy resilience of NSN both inside the base perimeter and outside the perimeter working with the local utility Dominion and other infrastructure utilities such as water.

OUTCOMES

- Work will clearly map resilience metrics that support mission readiness and the placement and specification of resilience nodes.

- SNL will be utilizing and validating multi-objective optimization techniques, including the Microgrid Design Toolkit, to formulate a more detailed system design for at least two resilience nodes.

- Make recommendations to key stakeholders.
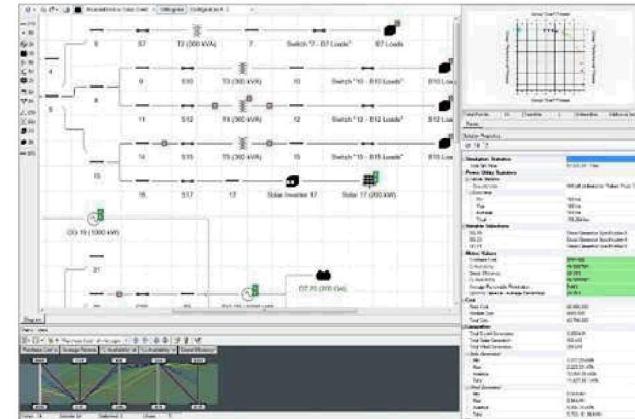
Energy Master Planning and Microgrid Feasibility Analysis

Energy Master Planning:
- Holistically considers all energy interventions for a district
  - Thermal and Electrical
  - Supply-side and Demand-side
- Has not classically incorporated resilience as a primary goal

Microgrid Feasibility Analysis:
- Weighs the costs and benefits of alternative microgrid designs
- Performs ~30% design level engineering analysis
  - Suitable for RFP or A&E firm involvement
- Often directly incorporates resilience as a goal or requirement
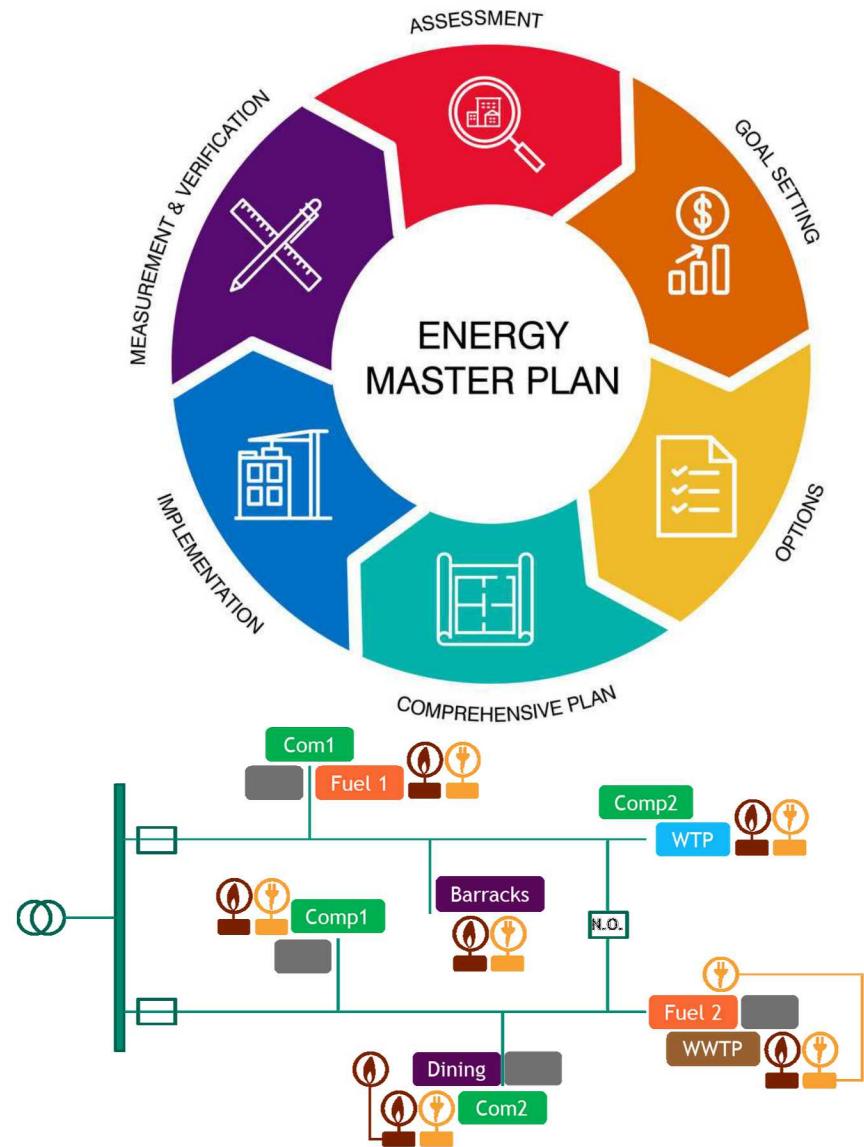
Norfolk Resiliency- Project Overview

Microgrid Design ToolKit

- Aids in the design of microgrid systems

- Used to illuminate the trade space of design alternatives when planning a microgrid

- Provides a variety of performance, reliability, and cost-related insights for candidate microgrid designs

MDT: Microgrid Design Toolkit – optimizes technology selection and sizing for individual microgrids based on multiple performance metrics

Norfolk Resiliency Project
Tasks and Milestones

2019

- In coordination with USACE-CERL under the International Energy Agency's Annex 73 project, this project contributed to international standardization of district energy planning methodologies by adding resilience planning.

The Resilience-Inclusive Energy Master Planning process developed by SNL and USACE.
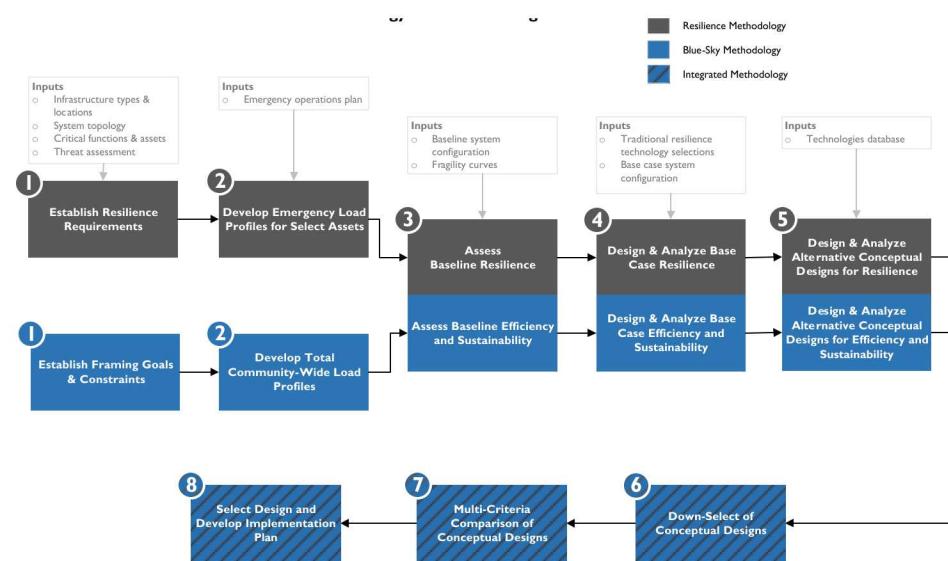
2020

- SNL received on January 28th, 2020 the geospatial information (location of buildings, electrical distribution system, other critical facilities) for NSN to date.

- We are analyzing the GIS info about base facilitates to determine electrical and water infrastructure layouts and connection to key NSN facilities.

- SNL has begun work on microgrid feasibility analysis for NSN in coordination with USACE in three areas corresponding to the first three steps in the Resilience Inclusive Master Planning Process.
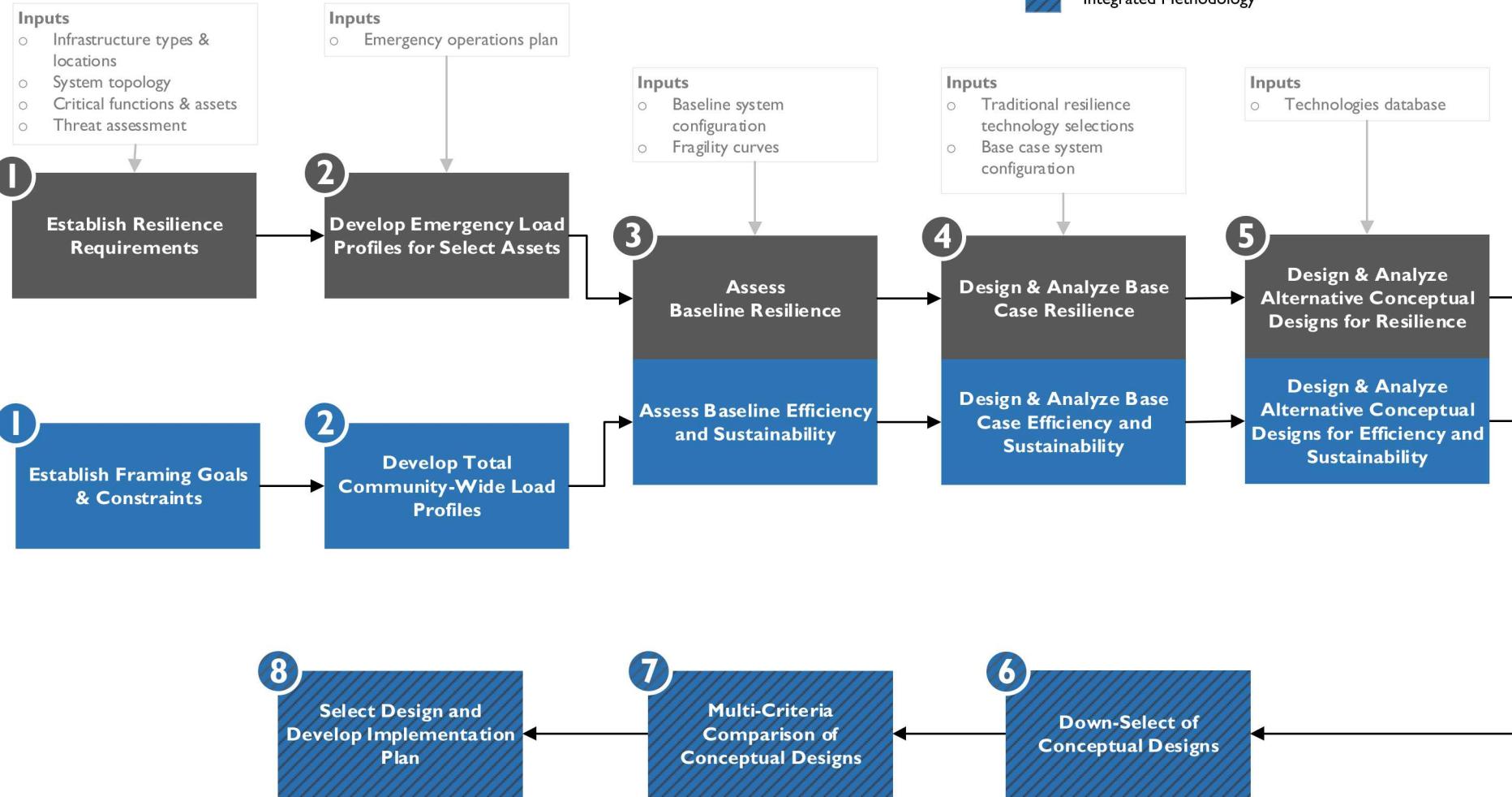
Step 1: Establish Resilience Requirements

Step 2: Develop Emergency Load profiles for select area

Step 3: Assess Baseline Resilience

Resilience-Inclusive Energy Master Planning Process

Legend:
- ■ Resilience Methodology
- ■ Blue-Sky Methodology
- ▨ Integrated Methodology

Inputs
- o Infrastructure types & locations
- o System topology
- o Critical functions & assets
- o Threat assessment

Inputs
- o Emergency operations plan

Inputs
- o Baseline system configuration
- o Fragility curves

Inputs
- o Traditional resilience technology selections
- o Base case system configuration

Inputs
- o Technologies database

1 Establish Resilience Requirements

2 Develop Emergency Load Profiles for Select Assets

3 Assess Baseline Resilience

4 Design & Analyze Base Case Resilience

5 Design & Analyze Alternative Conceptual Designs for Resilience

1 Establish Framing Goals & Constraints

2 Develop Total Community-Wide Load Profiles

Assess Baseline Efficiency and Sustainability

Design & Analyze Base Case Efficiency and Sustainability

Design & Analyze Alternative Conceptual Designs for Efficiency and Sustainability

8 Select Design and Develop Implementation Plan

7 Multi-Criteria Comparison of Conceptual Designs

6 Down-Select of Conceptual Designs

Jeffers, R., Wachtel, A., Zhivov, A., Thompson, C., Srivastava, A., and Daniels, P. (2019) *Integration of Resilience Goals into Energy Master Planning Framework for Communities*. ASHRAE Journal. *In Press.*

Norfolk Resiliency Project
Planned work for the next two quarters

Baseline resilience Assessment

- Continue process of evaluating the distribution system schematics for both the 4KV, 13KV and 34.5 KV feeders and substations and switching stations to determine the baseline resiliency capability and flexibility to the loss of service of substations for most if not all threat scenarios from flooding.

- Evaluate potential actions outside the fence include hardening of substations to the projected flooding of up to ~2.8 feet, which could improve reliability of service to NSN.

- SNL also began consideration of how resilience outside of the military installation can support operations within the installation. During extreme events, a portion of the effort ensuring mission readiness will be related to ensuring missions are served from remote locations. For instance, the Norfolk population includes over 80,000 active duty personnel, 112,000 family members and 30,000 civilians. Ensuring these people have access to critical infrastructure services, whether inside or outside the fence, is a key component of overall resilience for NSN.

Norfolk Resiliency Project Stakeholder engagement

Accomplished

- Teleconference meeting occurred on March 25th with City of Norfolk to discuss project scope. Key SMEs including Kyle Spencer and Chief Resilience officer Doug Beaver who was formerly the NSN base commander.
- Ongoing discussions with NSN community liaison officer and project POC to develop an approval process for NSN resiliency analysis results to be reviewed and vetted by DOD staff so they can be shared with DOE. Current strategy is to seek CNIC approval of DOE project scope.

Planned

- In person meetings with NSN station SME's, City of Norfolk and Dominion to identify the scope and footprint of a resiliency project to address both power and water disruption threats and risks.

Threat characterization

Resilience defined in relation to a threat or hazard

- Systems resilient to hurricane may not be resilient to earthquakes
- Include (but not limit to) threats with low probability but potential for high consequence
- Include probability of threat, when possible
- Estimate and include range of uncertainty when not possible

Threat categories:
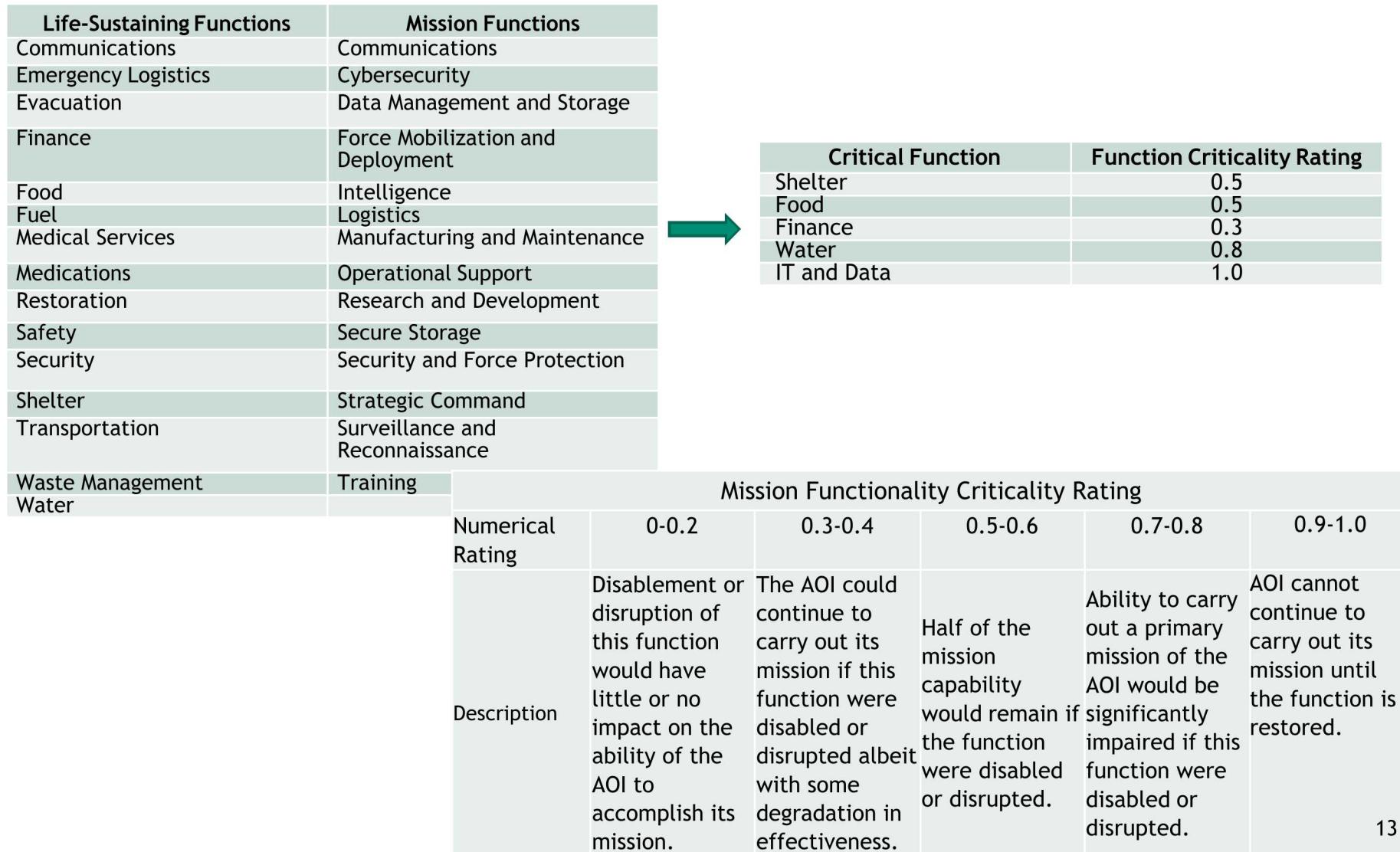
- Natural
- Intentional
- Accidental

Tools:

- HAZUS + GIS
- FEMA (flood, wind, quake, fire)
- USGS (landslide)
- NOAA (heat, cold, drought)

Inundation Level (feet)
- 1
- 2
- ● Infrastructure Point
- — Distribution Line
- Generator
- □ Switch

Flood Inundation Scenario Extents
- FEMA 100yr Flood
- FEMA 100yr Flood with 1.5 ft. of Sea Level Rise
- FEMA 100yr Flood with 3 ft. of Sea Level Rise
- Military Installation

Miles
0   0.5   1   1.5   2
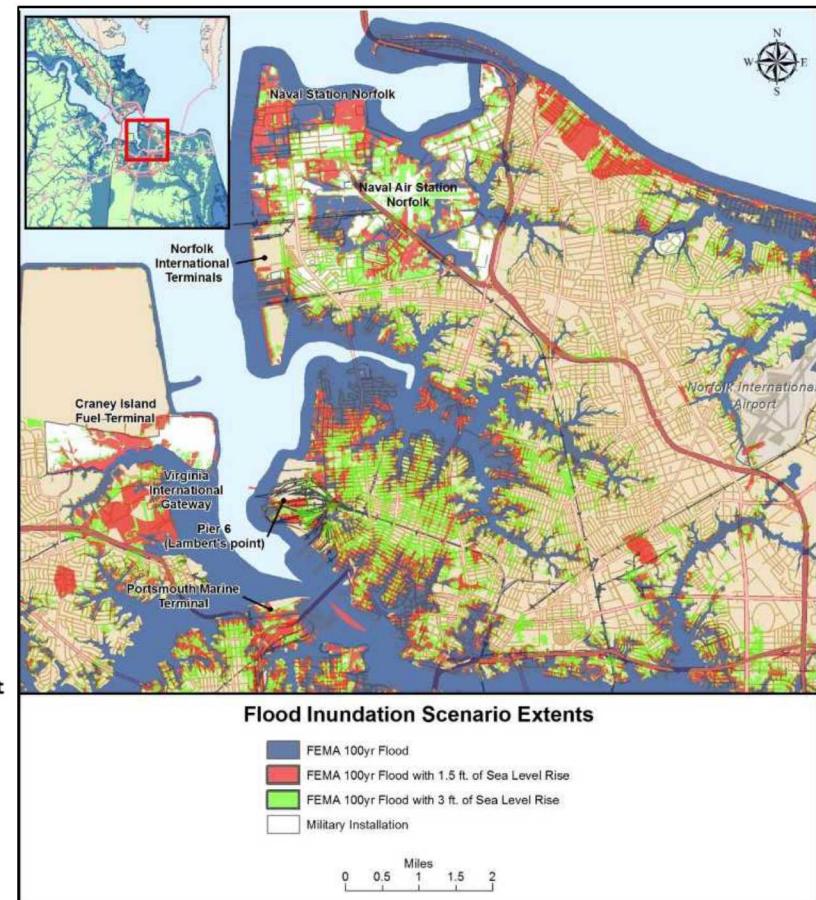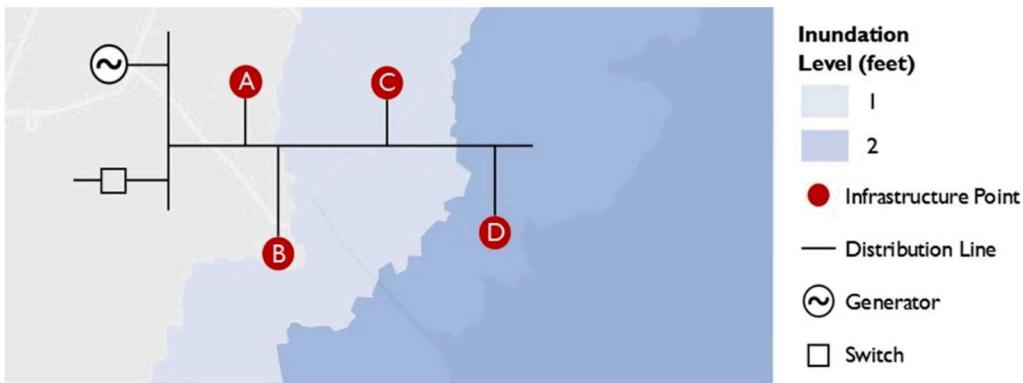
Mission prioritization

Identify mission essential functions, and their criticality to the overall mission (knowledge gap)

| Life-Sustaining Functions	Mission Functions
Communications	Communications
Emergency Logistics	Cybersecurity
Evacuation	Data Management and Storage
Finance	Force Mobilization and Deployment
Food	Intelligence
Fuel	Logistics
Medical Services	Manufacturing and Maintenance
Medications	Operational Support
Restoration	Research and Development
Safety	Secure Storage
Security	Security and Force Protection
Shelter	Strategic Command
Transportation	Surveillance and Reconnaissance
Waste Management	Training
Water	

Critical Function	Function Criticality Rating
Shelter	0.5
Food	0.5
Finance	0.3
Water	0.8
IT and Data	1.0

| Mission Functionality Criticality Rating					
Numerical Rating	0-0.2	0.3-0.4	0.5-0.6	0.7-0.8	0.9-1.0
Description	Disablement or disruption of this function would have little or no impact on the ability of the AOI to accomplish its mission.	The AOI could continue to carry out its mission if this function were disabled or disrupted albeit with some degradation in effectiveness.	Half of the mission capability would remain if the function were disabled or disrupted.	Ability to carry out a primary mission of the AOI would be significantly impaired if this function were disabled or disrupted.	AOI cannot continue to carry out its mission until the function is restored.

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Mission to asset mapping

Determine the level to which each asset (building, etc.) in the AOI can provide each mission essential function
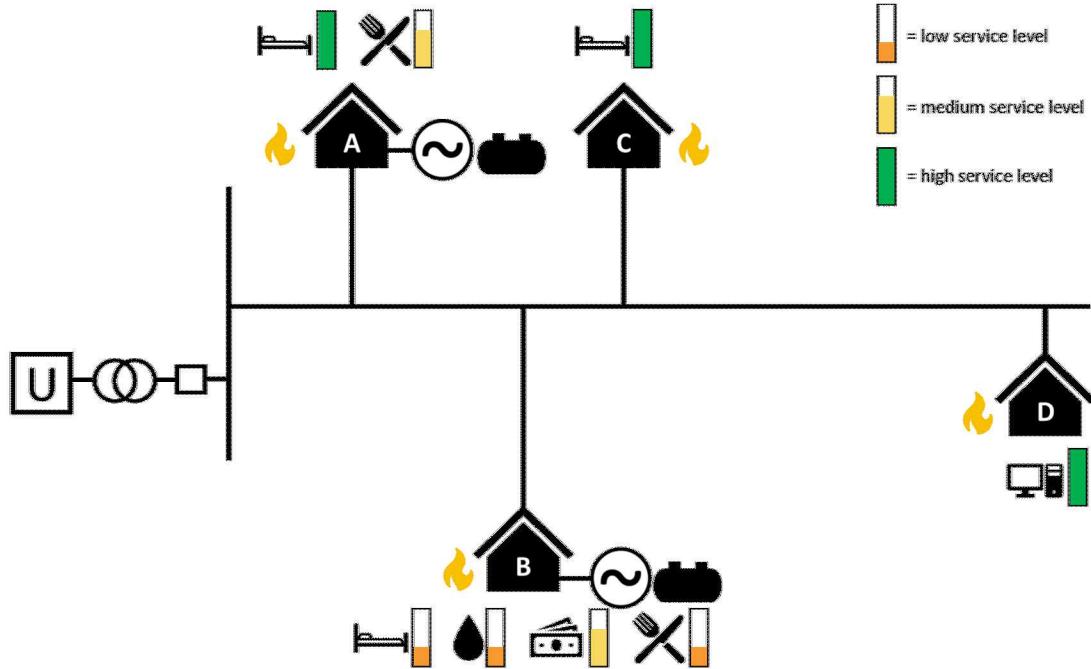
Critical Function	Building A	Building B	Building C	Building D
Shelter	1.0	0.5	1.0	
Food	0.75	0.25		
Finance		0.5		
Water		0.25		
IT and Data				1.0

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WNTR Norfolk Water Network Model
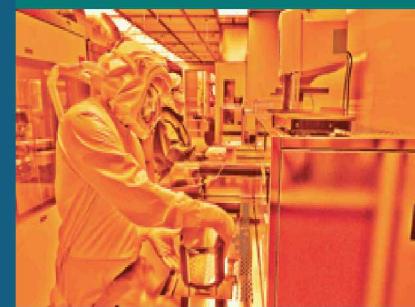
Katherine Klise, Daniel Villa, Joseph Hogge and David Hart

Water Network Tool for Resilience

- WNTR is a Python package designed to analyze water distribution network failure and recovery

- Simulation and analysis capabilities help water utilities predict how their system will respond to expected and unexpected incidents and inform decisions that improve overall resilience
  - Quantify resilience to a wide range of hazards, including pipe breaks, power outages, earthquakes, and cyber attacks.
  - Evaluate and prioritize resilience-enhancing actions

- The open source software has been downloaded over 36,000 times and used in numerous resilience studies by independent researchers

- Current users include US Environmental Protection Agency, Arcadis, Xylem, Mott McDonald, Los Alamos National Laboratory, and Naval Postgraduate School

WNTR

- Water distribution network model
- Hydraulic and water quality simulation
- Disaster models
- Probability of damage
- Response / mitigation actions
- Resilience metrics and analysis

https://github.com/sandialabs/wntr
http://wntr.readthedocs.io
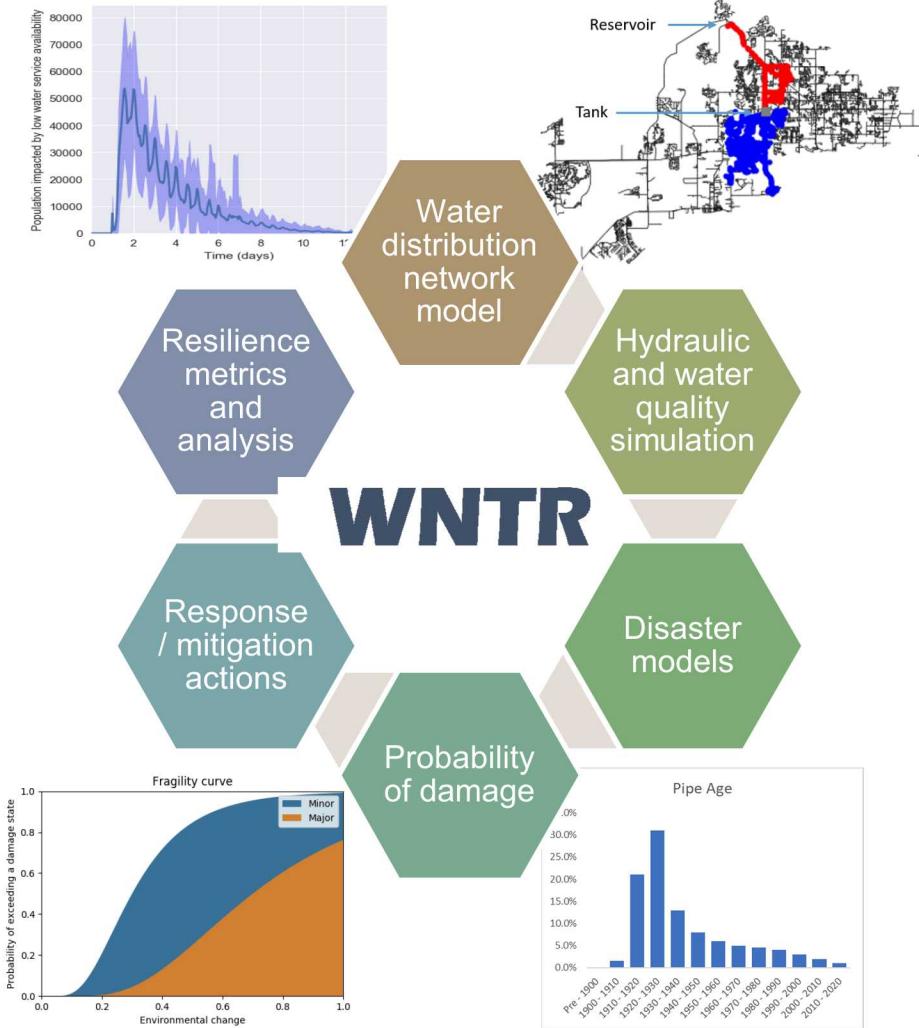
Water Distribution System Model Development

Norfolk Naval Station water distribution system model was created using WNTR and shape files from an Access geodatabase
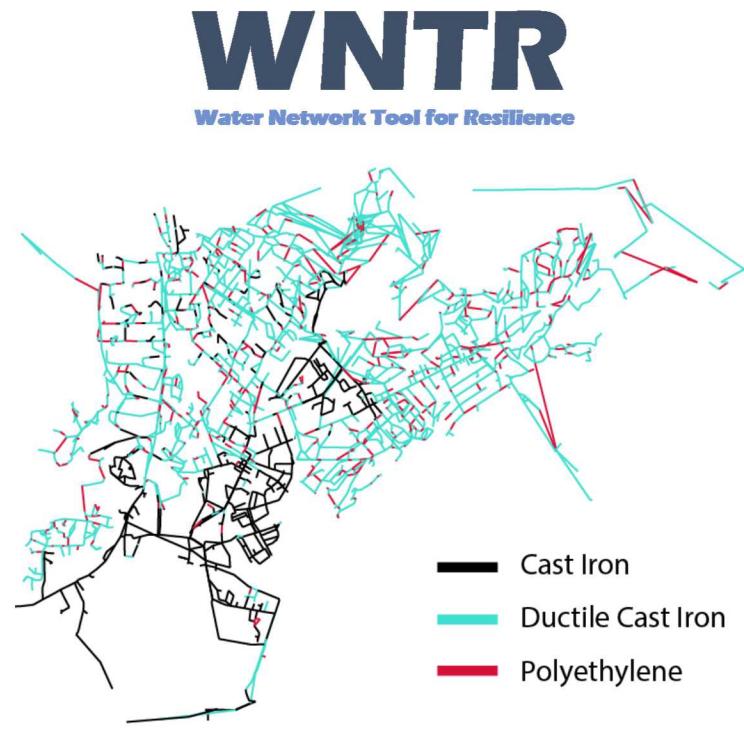
Automated process reads shape files into a Python routine which:
◦ Merges nodes within 0.4m of each other
◦ Infers missing diameters and pipe roughness
◦ Manual intervention was required for pipes that could not be reconciled, these pipes were assigned a large diameter to make their position obvious

Pumps, tanks, and valves are inserted by:
◦ Connecting the pump, tank, or valve to the network when the component is within a certain distance of an existing pipe
◦ Manual intervention will need to be added in areas where the routine creates incorrect inferences

The water distribution system model includes 16,000+ pipes in a single connected network.

WNTR
Water Network Tool for Resilience

— Cast Iron
— Ductile Cast Iron
— Polyethylene

The network shown above is for illustration only

Transparent Manual Corrections

The model building process creates a zoomed in view of diameters that could not be inferred that allows visual choices to be made.

Assign node 3802 diameter from pipes connected to node 3804

```python
class ManualDiameterAssignments(object):
    """This is a record of how I manually set diameters to values that I thought
    are correct based on visual observation of the network

    it is a dictionary of link numbers that are the template for a list
    of links that need the diameter of the template link

    """
    # Every link associated with the nodes should be reassigned diameters. The
    # node number for a template should reference a single link whose diameter
    # is the template for all of the link associated with the list.
    diam_manual = {12335:[12264,13895,15156,12336],
                   13897:[12343,6790,4931,6788,7375,2428,8763,4949,15166],
                   9427:[5473,5474],
                   428:[3202,531],
                   6747:[6720],
                   14745:[9539,9537],
                   6720:[6719],
                   11486:[14541,1166,3856,3857,1165],
                   2084:[15007,12179,12180,12181,12182,12183],
                   2141:[2142,13760,13761],
                   8519:[12173,12174,12175,12176,12177,12178,2110,2111,2112,2113],
                   10567:[10573,10574,10575,10576,2114,2115,2116],
                   2074:[12136,12137],
                   13774:[13768,13767,4611,4610,4609],
                   4585:[4583],
                   2093:[2094,2095,2096],
                   14457:[3580,3579],
                   3804:[3803,3802]}
```
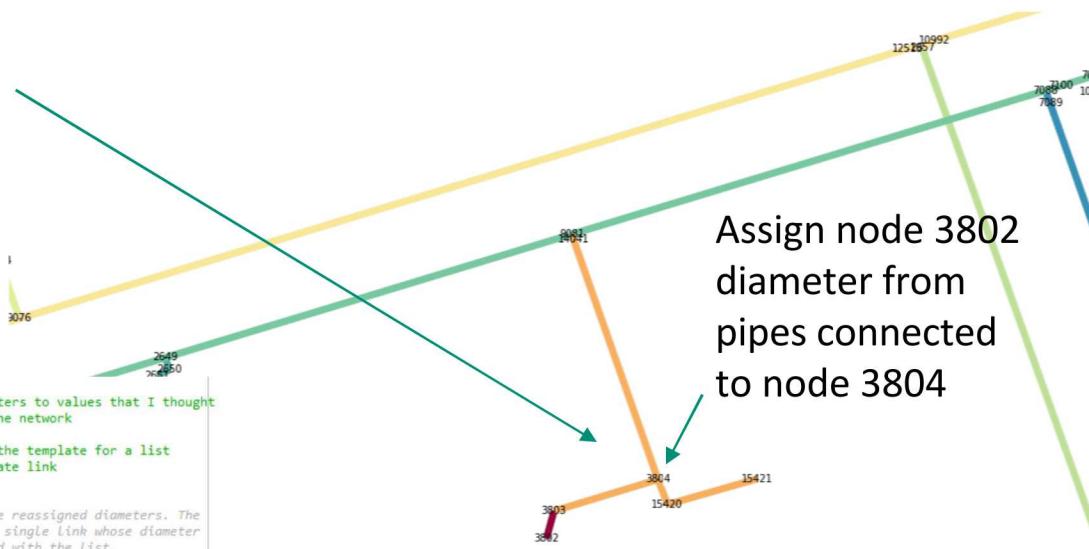
The python code includes all manual decisions to allow:
1. Transparency about decisions
2. Direct traceability to the original data source and the original data
3. Capacity to correct manual decisions while maintaining the streamlined process

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NSN water- Next Steps

Data requirements: The model requires additional data, including tank diameters, water demands, pump curves/power ratings, and operational data. Building footprint data could help define demands.

Model calibration: Calibration includes evaluation of flow data and control status to evaluate model quality.

Resilience analysis: The model can be used for resilience analysis, including:
- Contingency analysis to rank criticality of pipes, pumps, tanks, and valves.
- Power outage and source water analysis to establish how long the site can maintain water service in insolation.
- Additional threat informed resilience analysis is to estimate system response that could result from specific threats (for example, hurricanes or floods).

Number of people impacted by low pressure conditions for each pipe closure
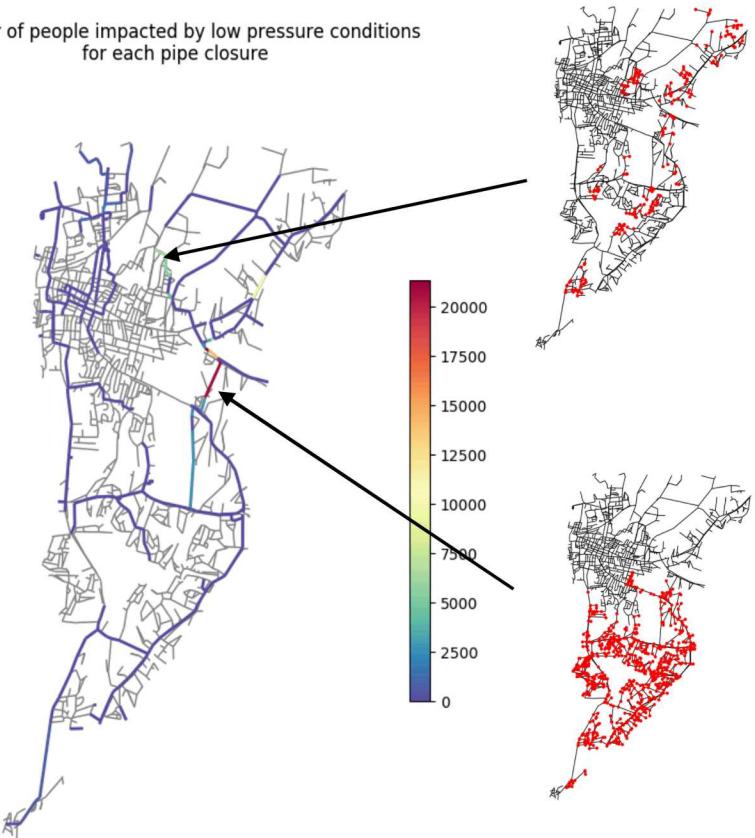
The network and analysis shown above is for illustration only. The Norfolk model is not yet calibrated but runs successfully in WNTR with constant pumping.

Pittsburgh, city of ~~bridges~~ microgrids

District Energy in Pittsburgh, PA

Northside District Energy
NRG Energy Center Pittsburgh

Currently serves 30 Buildings (including PNC Park, the Carnegie Science Center and Allegheny General Hospital)

Capacity:
240 Mlbs/hour of steam
20.4 MMBtu/hour of hot water
12,580 tons of chilled water

Brunot Island

Potential energy-from-waste plant adjacent to Allegheny County Sanitary Authority (ALCOSAN)

PACT

Downtown Energy District
Pittsburgh Allegheny County Thermal, Ltd (PACT)

Currently serves 59 Buildings (including City County Building, Allegheny Courthouse, the Westin and the Hilton Hotels)

Capacity:
500,000 lbs of steam per hour

Uptown EcoInnovation District

Uptown Energy District

Duquesne University has a cogeneration plant.
Posssibility for a new district energy system to serve the 28-acre Lower Hill site

IMAGINE LARIMER
A Green Neighborhood

Larimer Energy District

Possibility for a community microgrid system to serve 285 acre residential neighborhood redevelopment

CARNEGIE | MUSEUMS OF PITTSBURGH

University of Pittsburgh

Oakland Energy District

Carnegie Museum of Pittsburgh:
Bellefield Boiler
Capacity: 480,000 lbs/hour of steam
University of Pittsburgh:
Carrillo Steam Plant
Capacity: 690,000 lbs/hour of steam

Interconnected systems

ALMONO Energy District

Possibility for a district energy system to serve the 178 acre planned urban riverfront mixed use property development

Technical Approach – Tasks and Milestones

Pittsburgh

✓ Create system of resilience nodes that integrates with city resilience and sustainability planning

I.P. For one neighborhood, validate integration of thermal and electrical design considering both resilience and blue-sky value

Pittsburgh: Resilience Nodes

Worked with the University of Pittsburgh and Duquesne Light to validate critical infrastructure locations and conduct high-level analysis of potential microgrid locations using ReNCAT.

42 locations were identified and are shown in green. Next stage will focus on specific neighborhood within Pittsburgh.
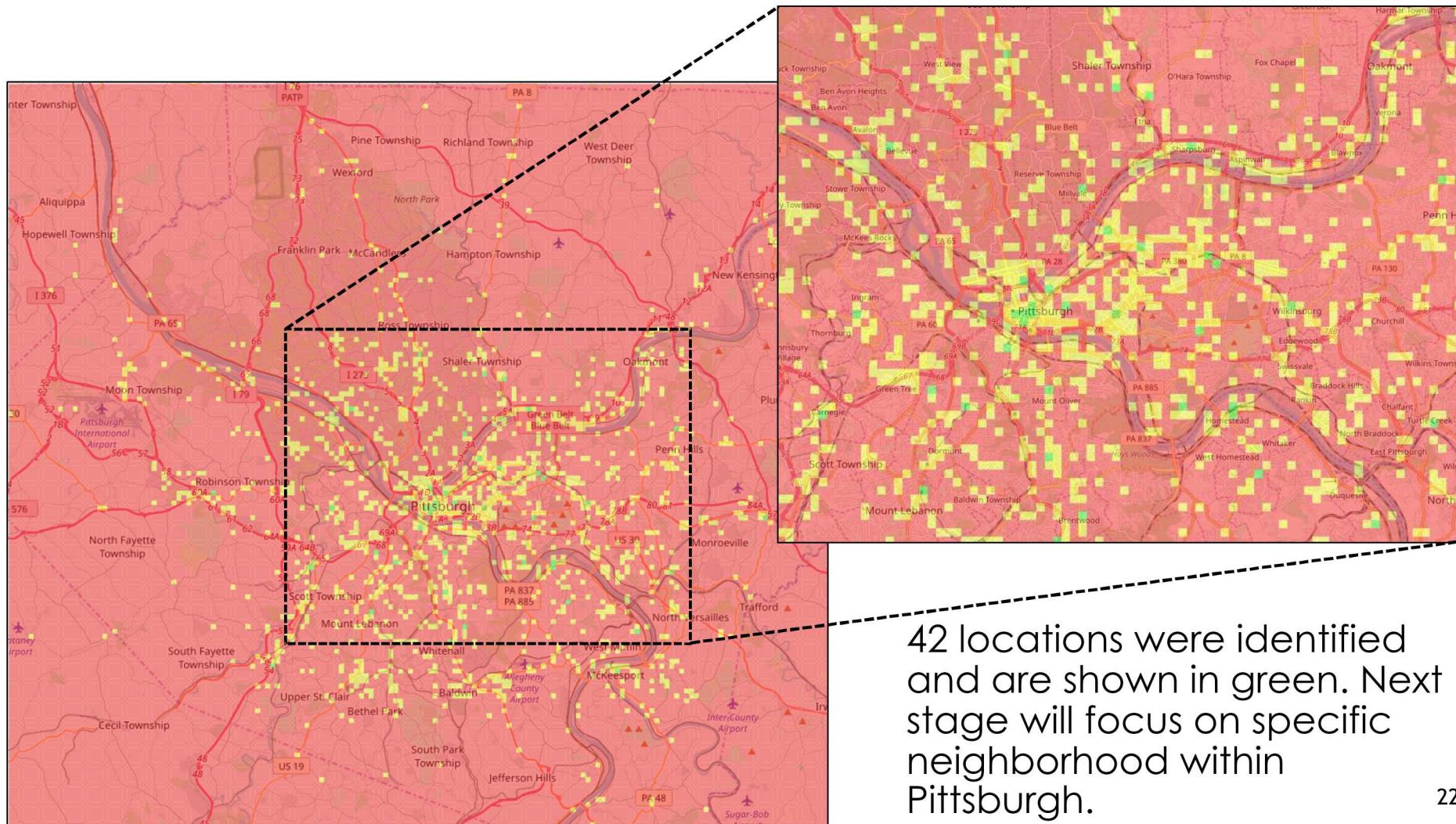
DER-CAM to balance thermal and electrical
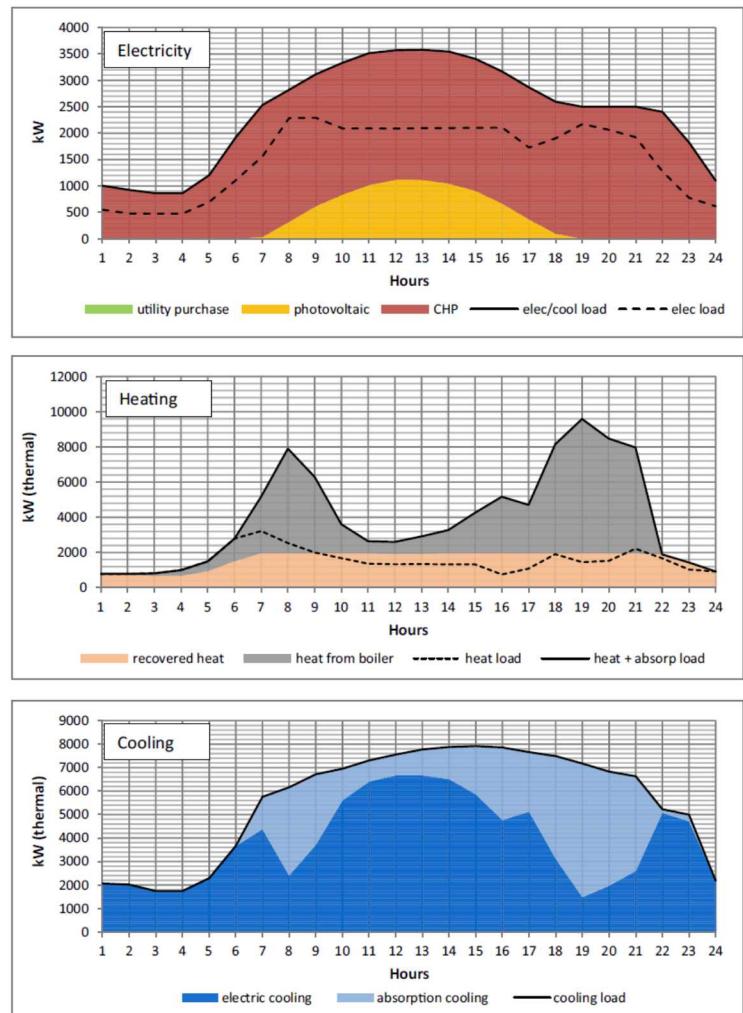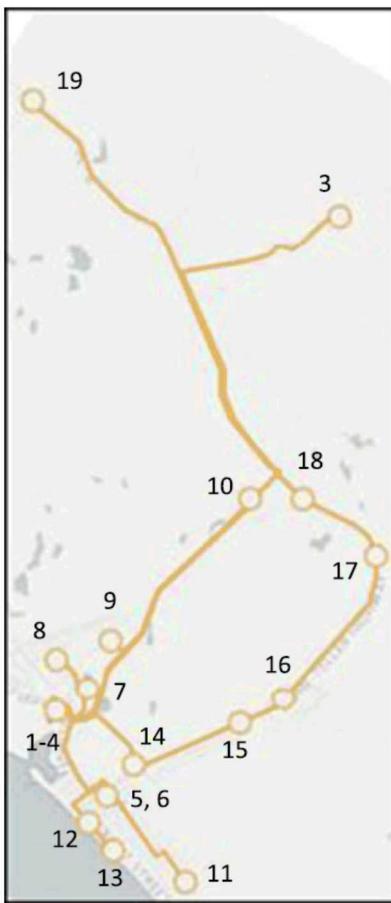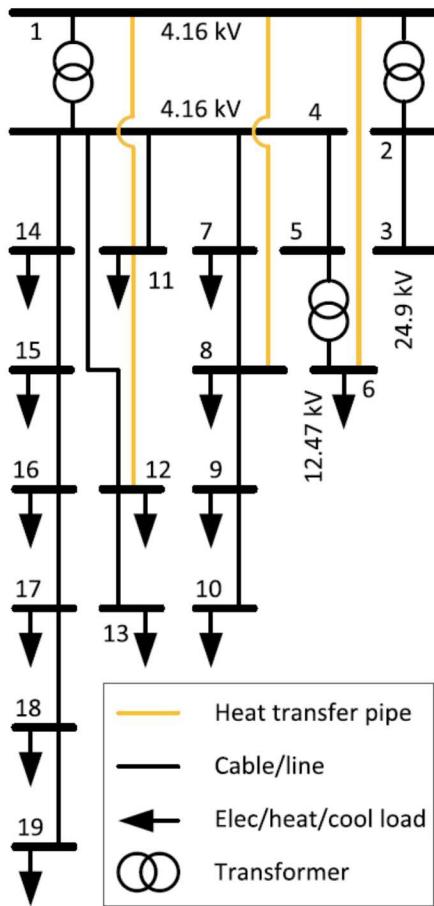
Mashayekh et al (2017), Mashayekh et al (2018)

Sandia is currently working with the City of Pittsburgh to identify a neighborhood to analyze the impact of building microgrids that balance blue-sky and resilience value given various thermal and electrical design options and constraints.

Pittsburgh Next Steps

1. Work with City of Pittsburgh to define analysis areas and collect data (in progress)
2. Finalize neighborhood DER-CAM models and iterate with stakeholders on results
3. Report to DOE on applicability of tools and methods (revision of above report)
4. Report to Pittsburgh and Duquesne Light on technical results

Conclusions

- This strawman process will be put through several case study iterations
- SME feedback will be elicited throughout the process
- Capability and knowledge gaps we know of:
  - Prioritization of mission-essential-functions (requires tight DoD coordination)
  - Standardized targets for resilience metrics (EA and MD) for each mission function
  - Development of load profiles for both normal and emergency operations
  - "True" co-optimization of installation-wide designs for:
    - Blue-sky and resilience metrics
    - Electrical and thermal systems
  - Multi-criteria decision analysis support for final decision-making
  - Validation of systems models
    - System operation during threats that have never been experienced

THANK YOU

- Robert Broderick (rbroder@sandia.gov)
  - Bobby Jeffers (rfjeffe@sandia.gov)

Back-up Slides

1a. System Topology and Assets

Understand key characteristics of the area of interest (AOI)

- Building types, critical functions -> energy use (loads)
- Energy system topology (thermal and electrical)
- Often useful to start with geospatial information (GIS)

Military Installations	Hospitals	Campuses	Public Housing
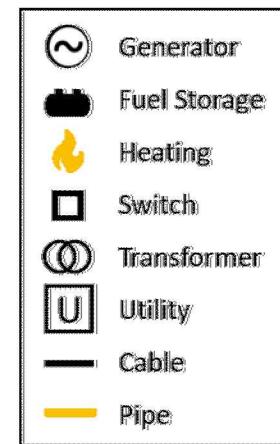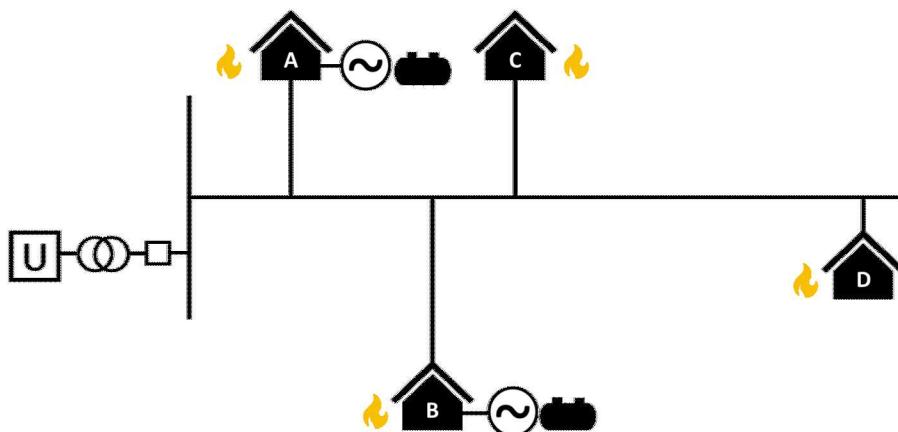
2. Emergency and Blue Sky load estimation

24-hour and 8760-hour load profiles are different during emergency vs. normal operations.

- Tools:
  - Energy Plus building models and load profile databases (improvement opportunity)
  - SME input
  - Meter data
  - Simulation of mission requirements during emergency (capability gap)

| Typical Operation | Grid Failure Operation |
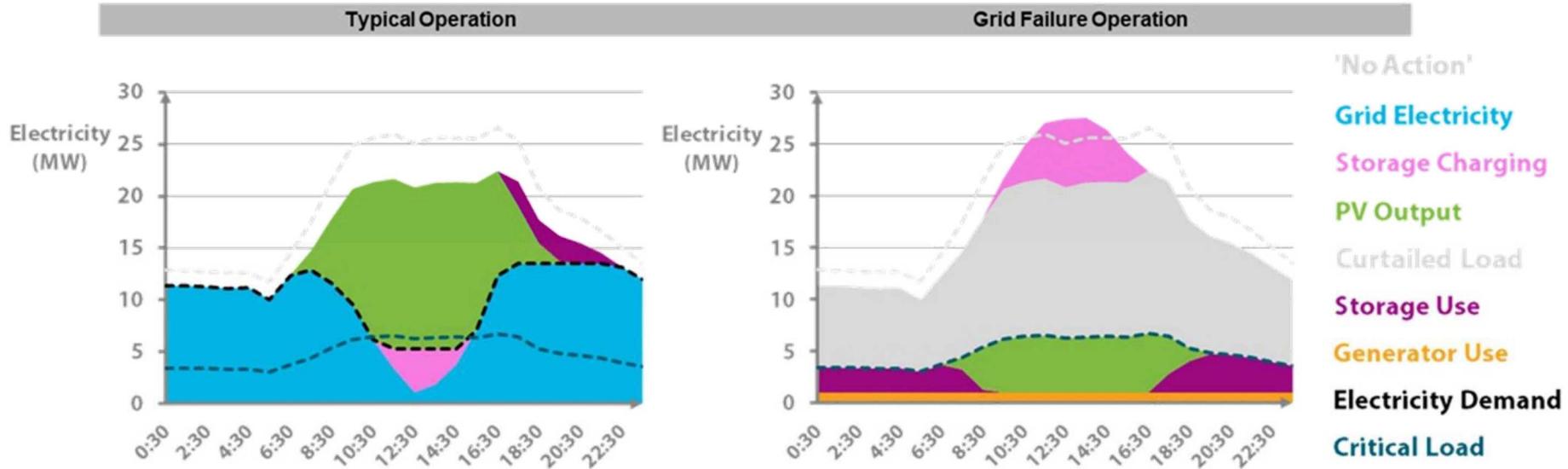
3. Baseline Risk Assessment

- Further develop resilience metric targets (based on goals assessment in step 1)
  - (Knowledge gap)
- Perform baseline risk quantification and populate baseline resilience metrics

$$Energy\ Availability = \frac{Energy\ Served}{Energy\ Demanded}\Bigg) \qquad E(EA) = \frac{\sum_{i=1}^{n} p_i * EA_i}{\sum_{i=1}^{n} p_i}$$

Critical Function	Required		Baseline	
	Energy Availability	Max Allowable Outage Duration	Energy Availability	Max Observed Outage Duration
Function A				
Function B				
Function C				
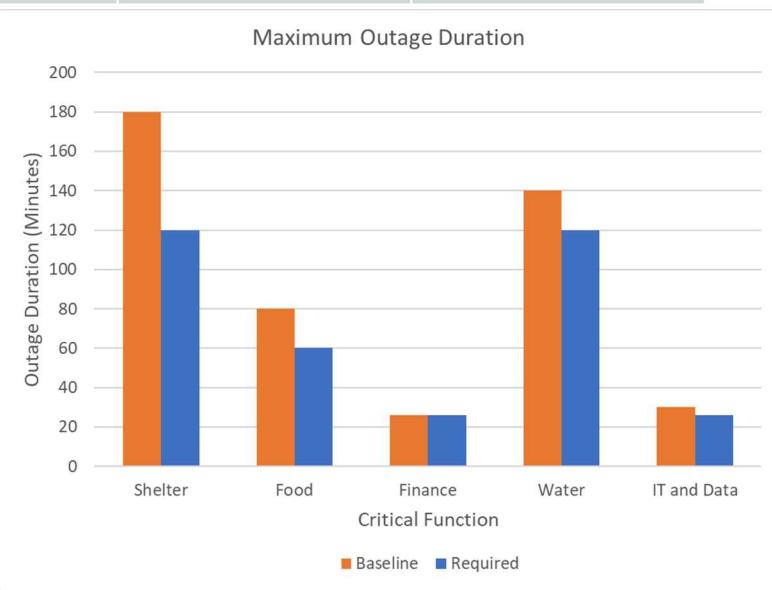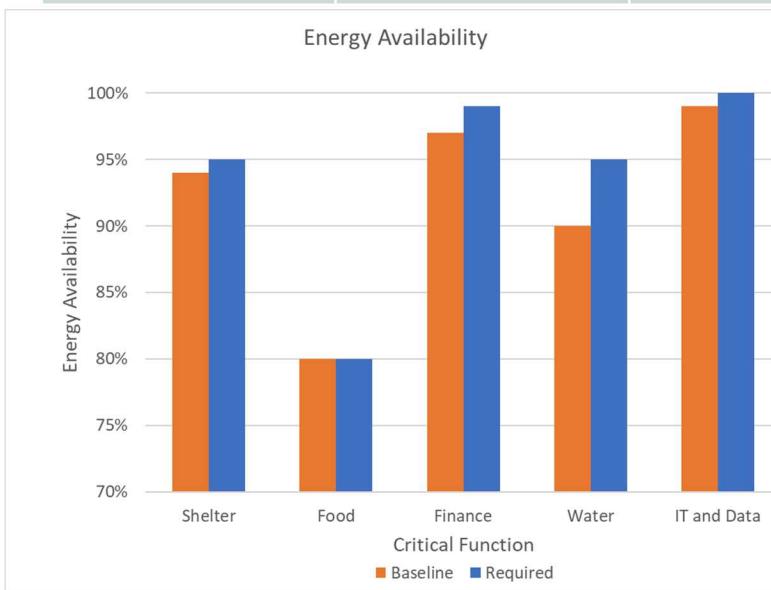
4. Base Case Designs

- Two separate designs to achieve blue sky and resilience metric targets
- Chosen from a list of pre-approved solutions
- Similar to the "business-as-usual" case
- Helps develop a cost basis for comparison
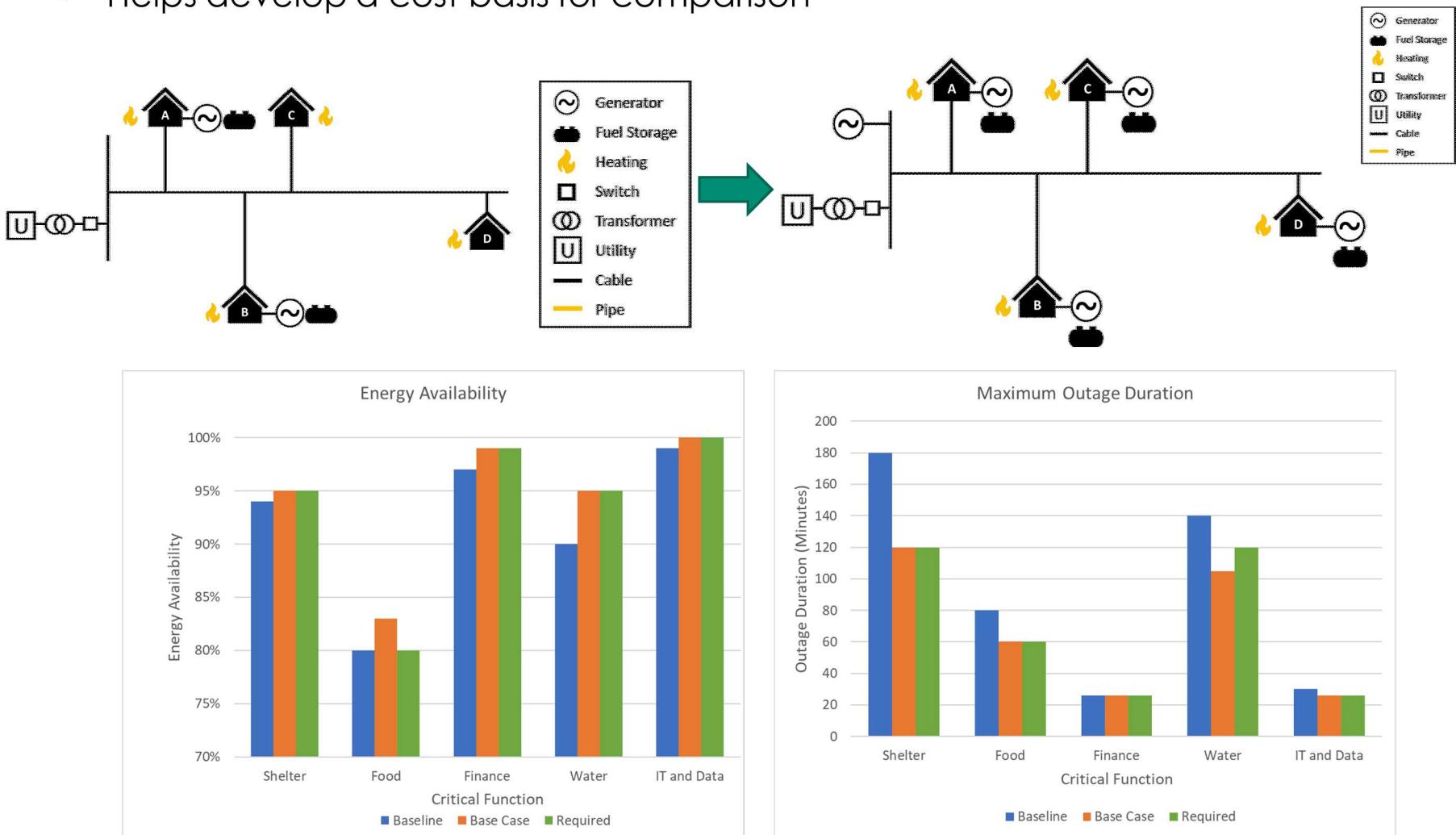
5. Alternative Designs

- Designs that consider blue-sky and resilience benefit streams TOGETHER
- Ideally use co-optimization (capability gap)
- Consider more advanced technologies (microgrids, district energy, grid-forming inverters, alternative topologies, etc.)
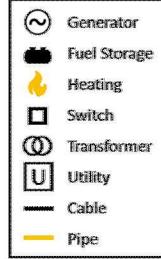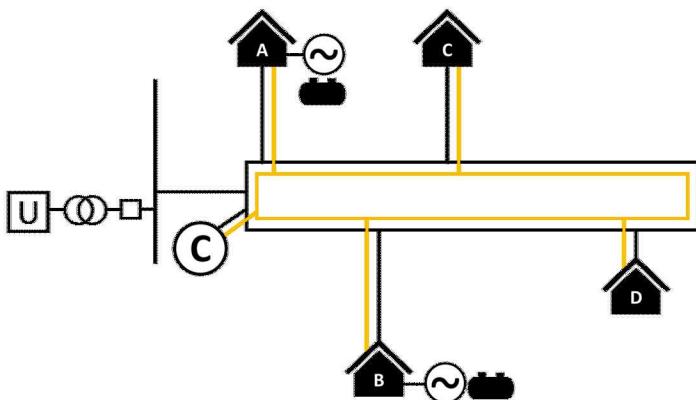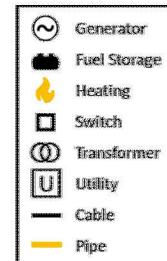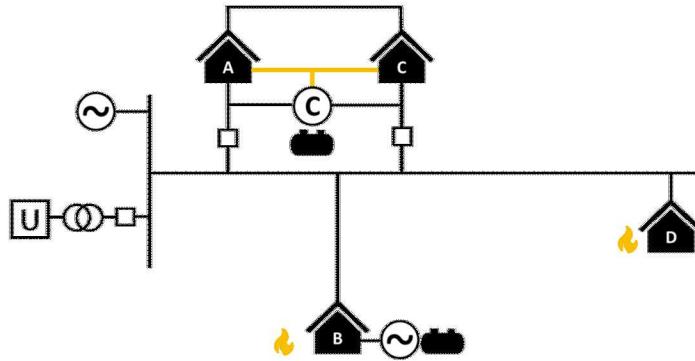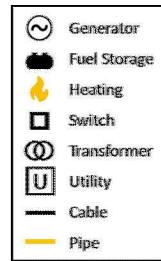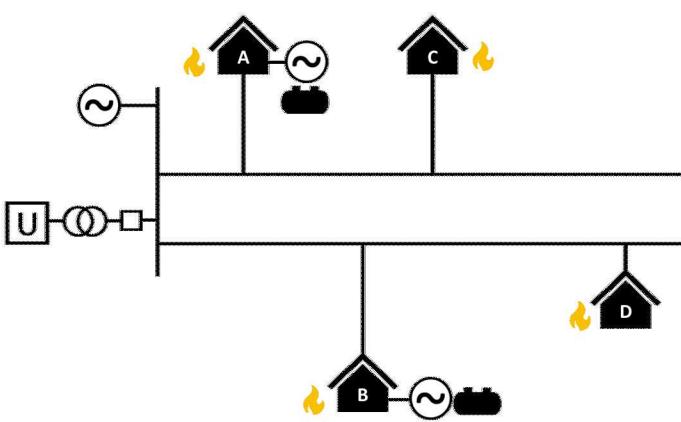
6. Multi-criteria decision analysis

- Assess the relative benefits of blue sky performance vs resilience performance
- Collapse into a single blue sky and resilience performance dimension (optional)

$$Blue\ Sky\ Performance =$$
$$EOLvalue - CapEx -$$
$$NPV(ElecPurchase + Gas\ Purchase + O\&M + EmissionsCost)$$

$$Resilience\ Performance$$
$$= \frac{\sum_{i=1}^{n}\left[FC * 0.5 * [Achievement(EA) + Achievement(MD)]\right]_i}{\sum_{i=1}^{n} FC_i}$$

$$Achievement(*)$$
$$= \begin{cases} 0, metric < target \\ 1 + a * (metric - target), metric \geq target \end{cases}$$
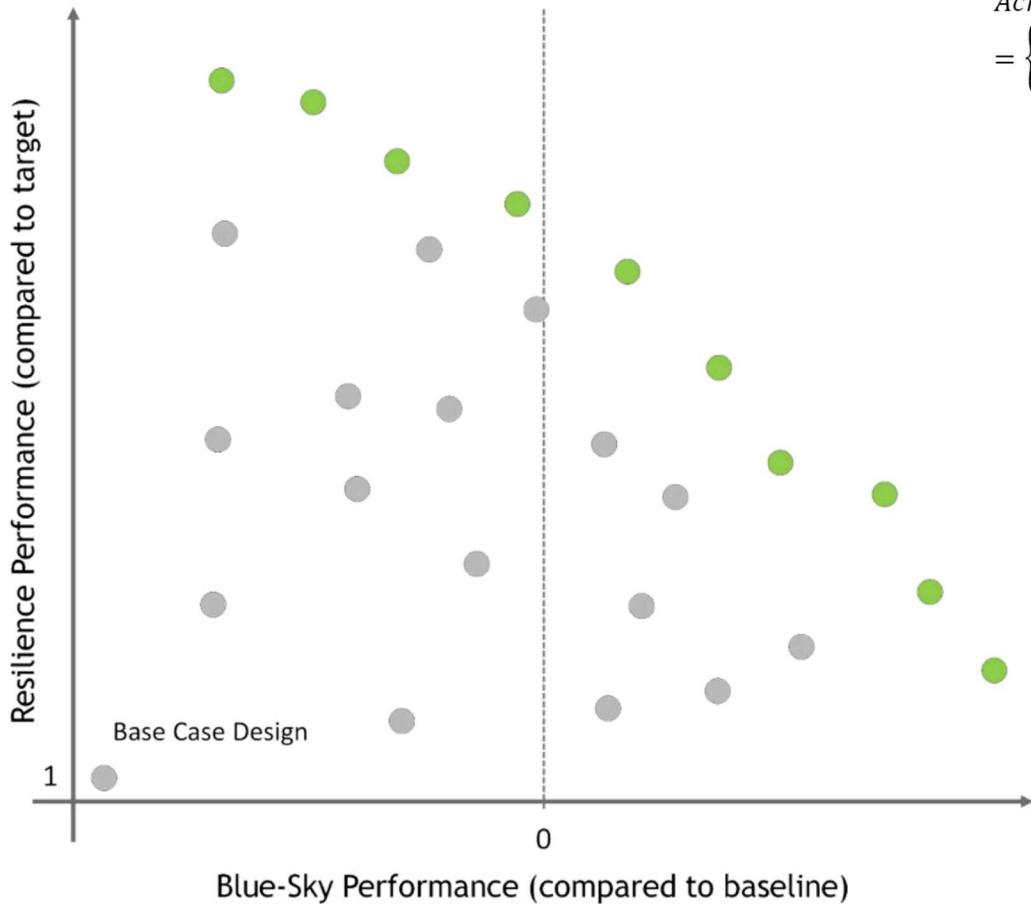
FC = function criticality
EA = Energy Availability
MD = max outage duration
*n = number of mission essential functions*

Resilience Performance (compared to target)

Base Case Design

1

0

Blue-Sky Performance (compared to baseline)

Tradeoffs: Efficiency, Sustainability, and Resilience

Comparing Resilient, Sustainable, and Efficient Systems
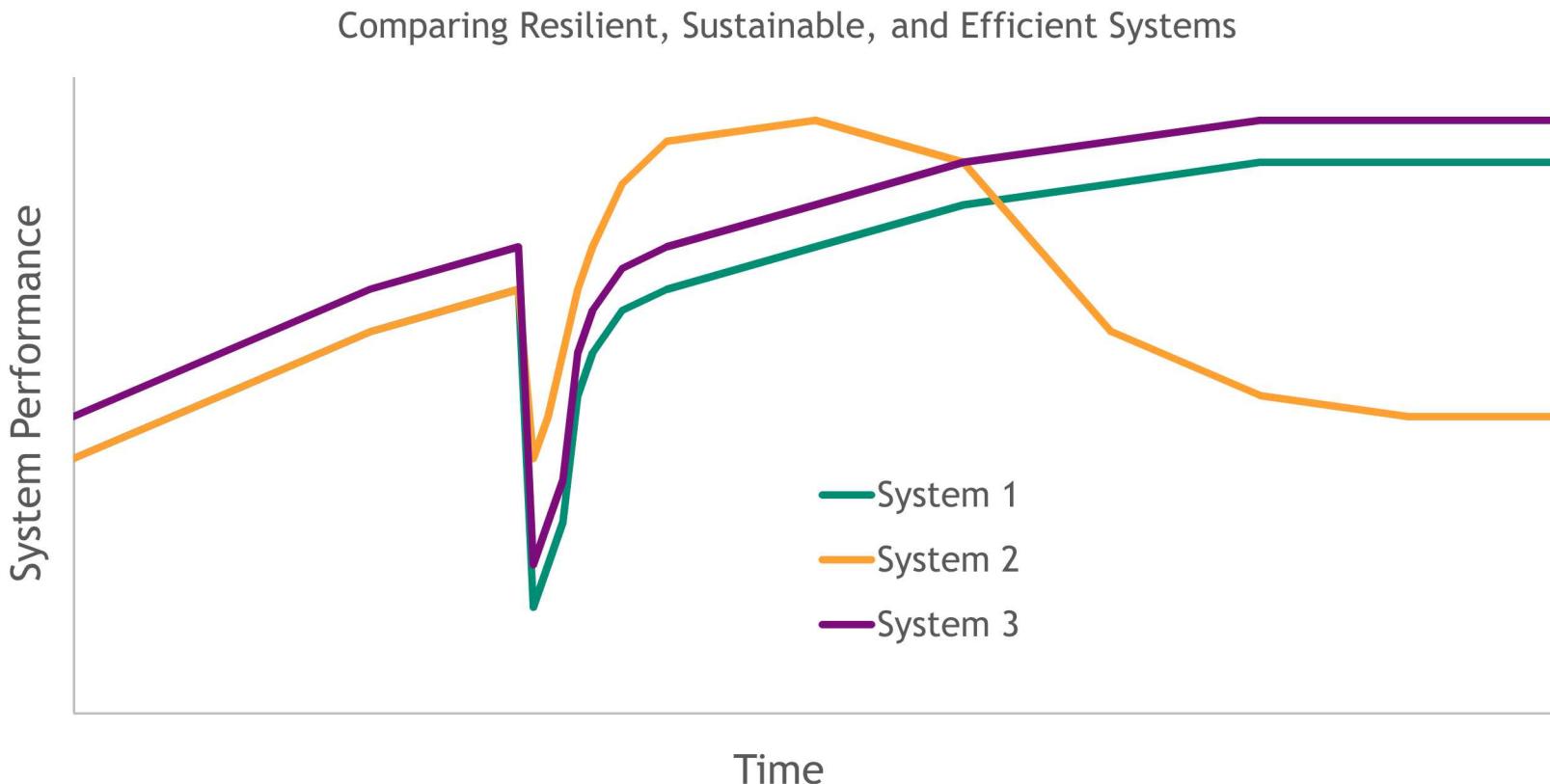
Tradeoffs between resilience, efficiency, and sustainability require integration of planning and analysis techniques

Resilience for Distribution System Planners

Histogram of Customer Minutes Interrupted, Selected Causes

Customer Minutes Interrupted (bins)

Consequences

Customer Minutes Interrupted (Filter)
0 to 2000
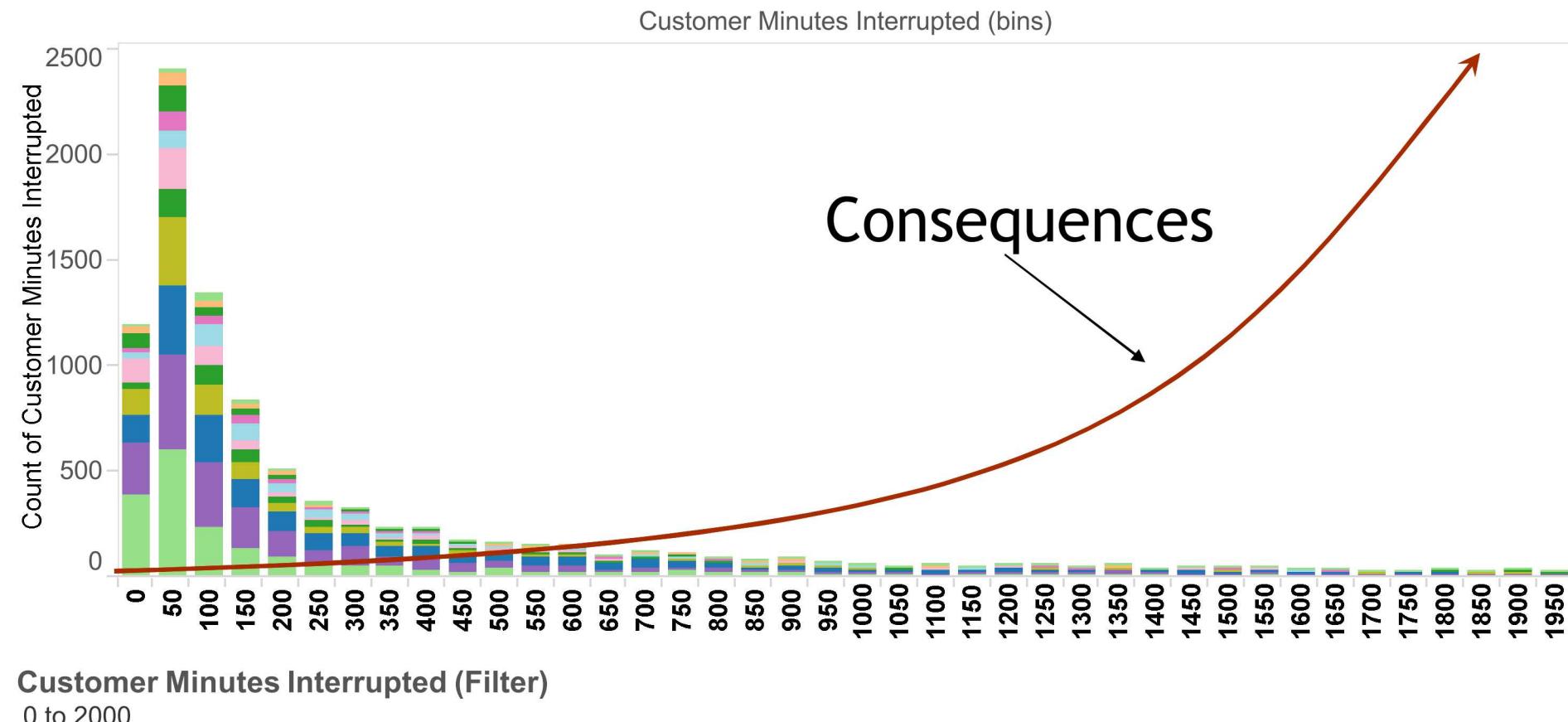
Power system planners currently use reliability metrics and criteria to ensure a reliable grid. We are still working on standardized and accepted practices for resilience.

GENERIC METHODOLOGY

Threats – What we want to be resilient against

Impacts – How those threats manifest physically

Performance – Goods and services provided to people by infrastructure

Consequence – How people are impacted by the infrastructure performance

THREATS → IMPACTS → PERFORMANCE → CONSEQUENCE

Hurricane
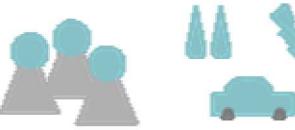
High Winds
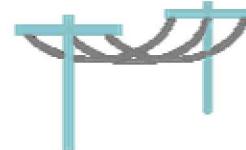
Power Served

Gross Municipal Product

Flooding

Inundation

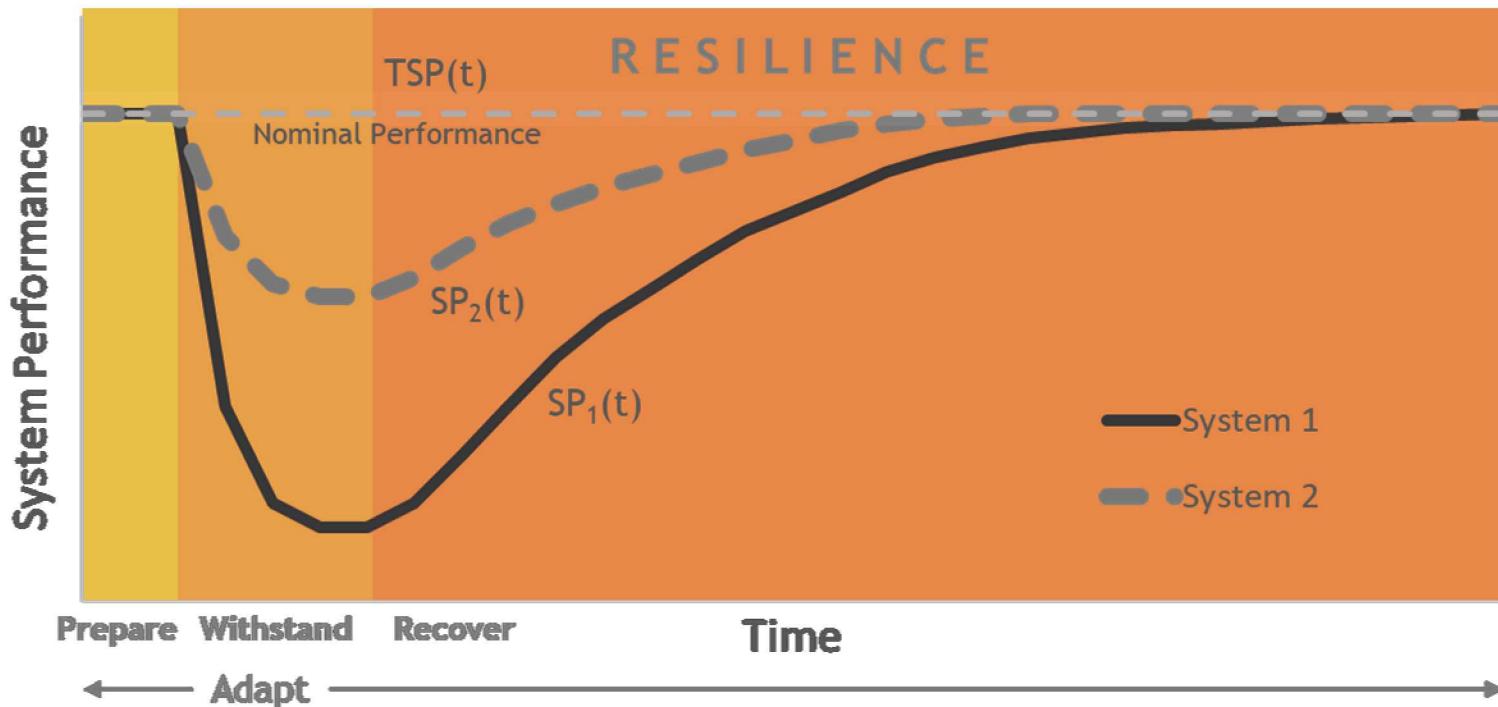Commute Time

People Without Services

Heatwave

Overloading

Water Served

Total Population

Mathematical Framework for Energy Resilience

1. Resilience is contextual – defined in terms of a threat or hazard
   - A system resilient to hurricanes may not be resilient to earthquakes
2. Includes hazards with low probability but potential for high consequence
   - Naturally fits within a risk-based planning approach

What is your system? How do you define performance? What threats do you want to be resilient to?

In other words: What keeps you up at night?

Quantifying Consequence

Measure Classification	Common Examples
Community Measures	Number of People Without Necessary Services
	Lives at Risk
	Societal Burden to Acquire Services
Economic Measures	Gross Municipal Product / Net Economic Losses
	Change in Capital Wealth
	Business Interruption Costs
National Security Measures	
	...

Planners can use metrics of consequence to their communities to define and plan for resilience
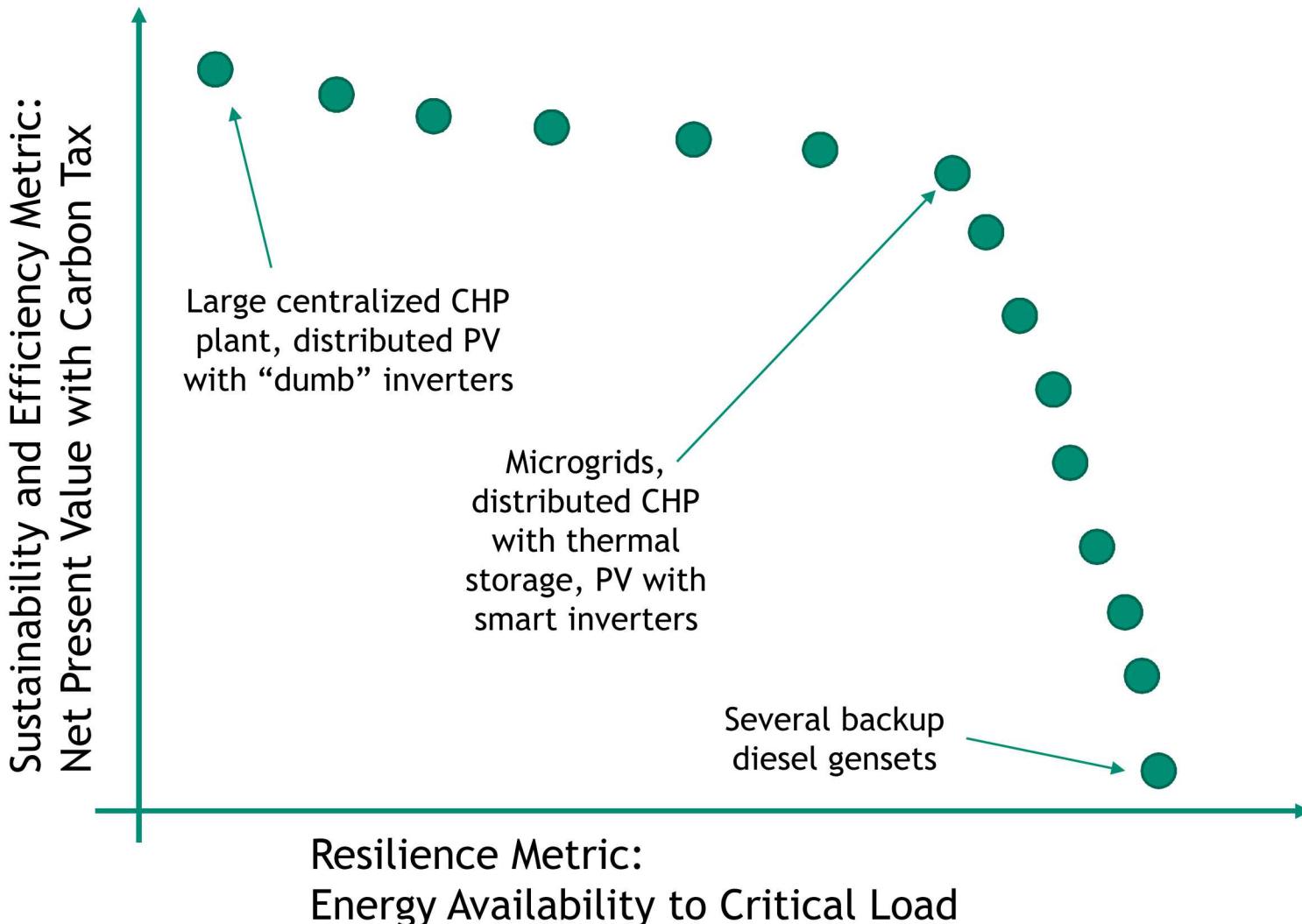
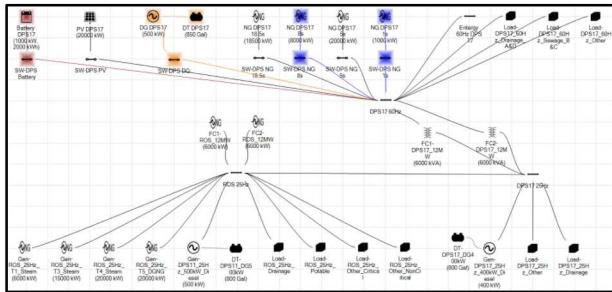# Consequence-Focused Metrics for Planning
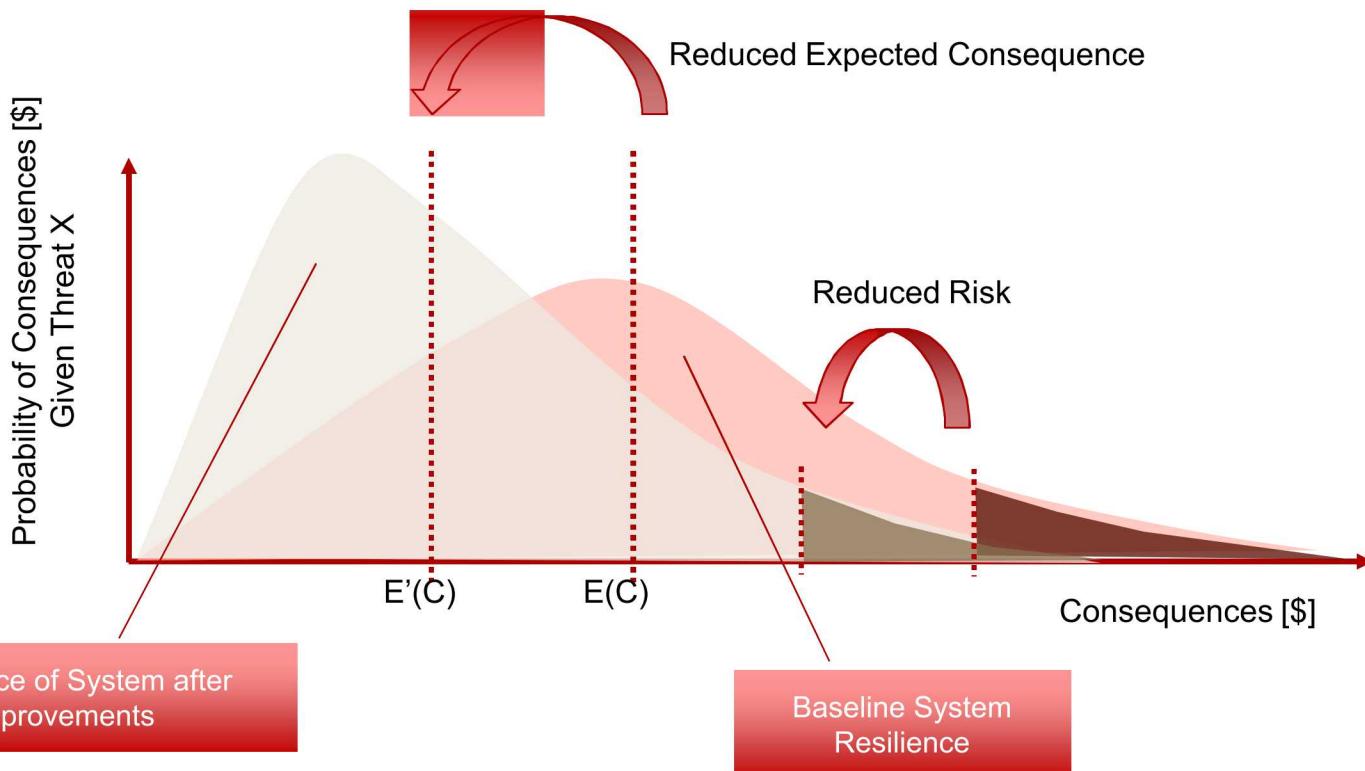
Using a probabilistic risk analysis approach:

- Model or measure the performance of the power system subject to threats
  - Cover a range of events from low-probability/high-impact to high-probability/low-impact
- Generate histogram of outage duration vs. frequency at all nodes
- Convert histogram of outage duration to consequence-focused metric
  - Often uses another model
- Propose investments and perform these steps again
- Optional: weigh resilience metrics against other goals such as efficiency and sustainability

Ultimate goal: understand tradeoffs between metrics in order to select a design that meets all targets at least cost

Sustainability and Efficiency Metric: Net Present Value with Carbon Tax (y-axis)

Resilience Metric: Energy Availability to Critical Load (x-axis)

Large centralized CHP plant, distributed PV with "dumb" inverters

Microgrids, distributed CHP with thermal storage, PV with smart inverters

Several backup diesel gensets

Co-optimizing microgrid designs for blue-sky and resilience value

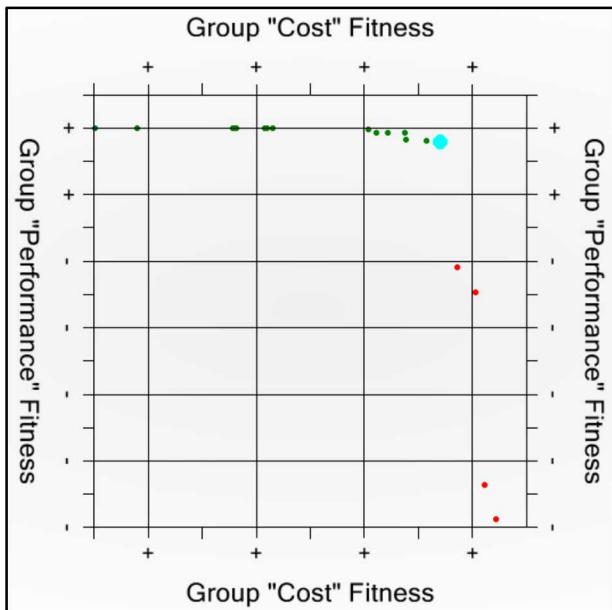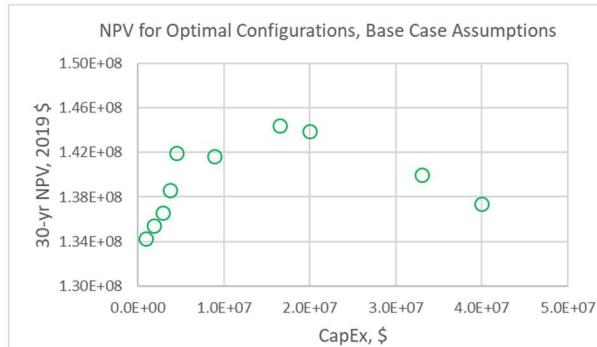## Resilience Optimization

Integration

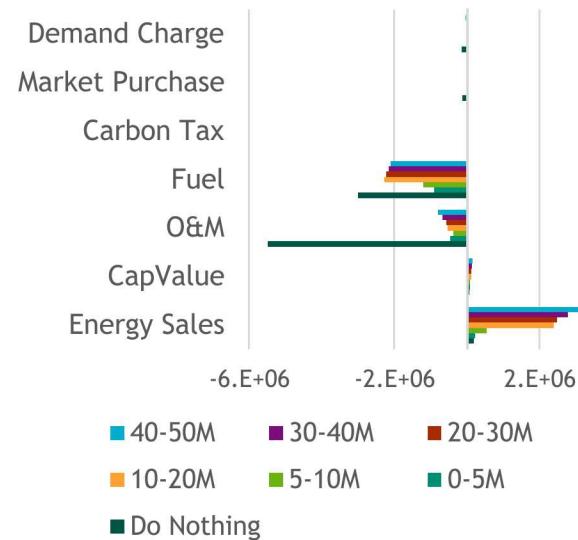## Blue Sky Optimization

Run blue sky model, include a value of:

- Sustainability: $0.01 / kg avoided CO_2 (discuss)
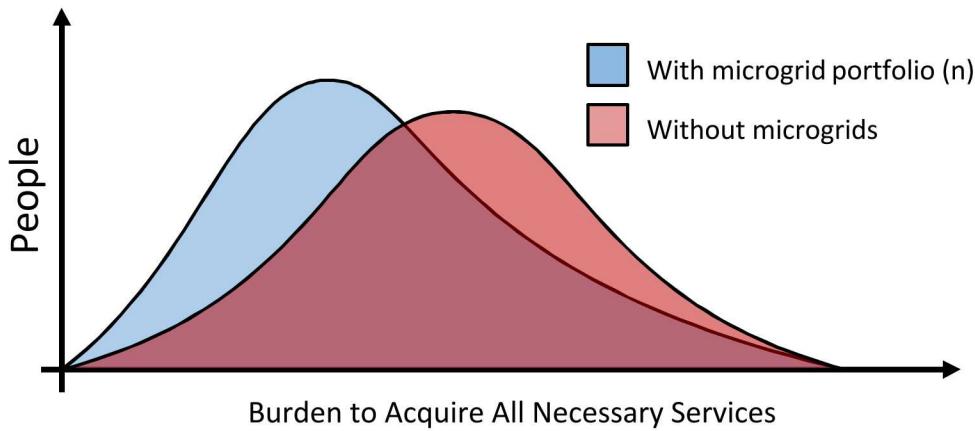- Resilience: $50/kW capacity value (discuss)

City most interested in:

- Payback period
  - (6-10 years)
- Net present value
  - ($150-270M over 30 yrs)
  - ~$100M CapEx
- CO_2 avoided
  - (6.2 M tonnes)
- Improved resilience
  - From ~74% to ~99% energy availability to critical loads

Infrastructure Performance -> Social Consequence

Advancing metric calculation for grid investment portfolio evaluation

With microgrid portfolio (n)

Without microgrids

$$B_C = \sum_{inf} \sum_{pop} \frac{E_{inf,pop}}{A_{pop}}$$

People

Burden to Acquire All Necessary Services

Effort
Average distance traveled
to acquire service

Ability
Median household income
for census block group

Burden

Jeffers et al. (2018) Analysis of Microgrid Locations Benefitting Community Resilience for Puerto Rico. SAND2018-11145
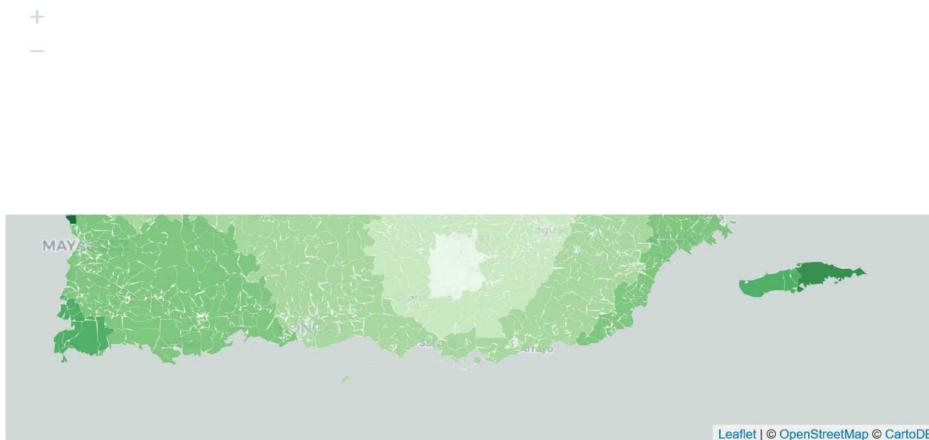
How is resilience integrated into Energy Master Planning today?

DOE tools:

DoD tools:

Commercial and other tools:

All tools share some basic concepts, but differ in some regards

Different tools can assess different pieces of the puzzle

"Blue Sky" Analysis

"Black Sky" Analysis

- Minimum CapEx + OpEx
- Maximum ROI

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

Simulation

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

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

Thermal + Electrical

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

1. Establish Blue Sky and Resilience Goals / Requirements

Given a set of energy-dependent mission functions, design the most cost-effective energy system to meet mission needs considering all hazards the energy system may face.

Sustainability:

- Meet requirements for renewable integration
- Decrease emissions below a threshold of acceptability

Efficiency:

- Minimize total cost of energy served during normal operations (includes capital, O&M, etc.)

Resilience:

- Decrease consequence of hazards below a threshold of acceptability

Resilience   Sustainability

Resilience-
Inclusive
Energy
Master Plan

Efficiency
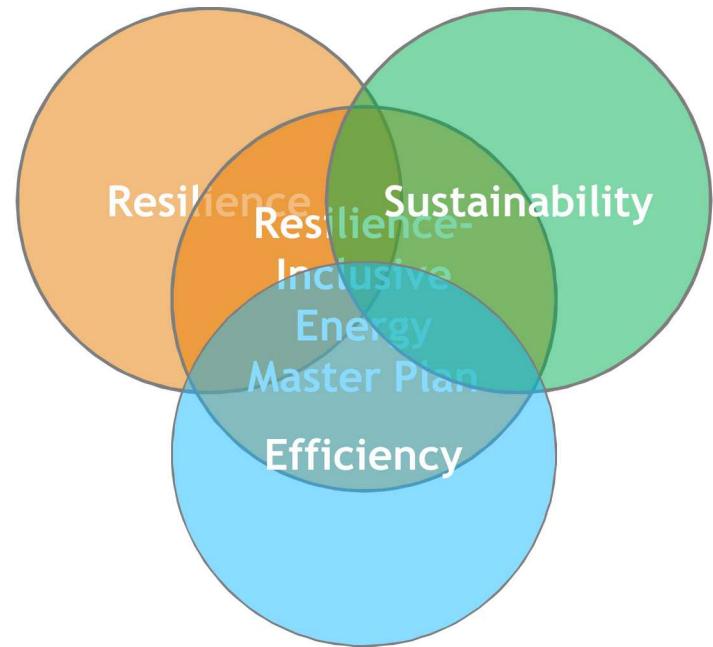
Activities for the next two quarters

- Exercise process with Naval Station Norfolk supporting a more integrated Installation Energy Plan. Partner with City of Norfolk and Dominion Energy to show benefits of resilience outside-the-fence to national security. (One more installation is TBD.)

- Collaborate with Defense Energy team to vet and improve this process.

- Integrate aspects of the Controls/Operations and Cyber/Comms teams as part of an overall high-level Defense Energy planning process.