The Resilience Analysis Process (RAP)

The project team is utilizing the Resilience Analysis Process from Sandia National Laboratory to develop a resilience roadmap for electric power in North Carolina. The RAP is a stakeholder driven process that has several stages. It begins by developing a set of community resilience goals. These are targets that the community believes must be achieved in the aftermath of a major event. Experts then work with the community to develop numeric metrics that can quantify the success in achieving these goals. The team then works to identify and characterize the various threats faced by the community. Once these are understood, the team can use the metrics as a means of evaluating whether different grid-modernization options allow the community to cost-effectively meet its resilience goals.

Example: The City of New Orleans

The City of New Orleans recently collaborated with Sandia National Laboratory and its local utility, Entergy, to develop a resilience plan for the city. Hurricanes were obviously a major concern for local citizens. Figure 1 shows the progress of power restoration after the landfall of recent hurricanes that have impacted the city. Note that most storms initially impact hundreds of thousands of customers. Depending upon the severity of the storm and the amount of flooding and wind damage, the outages can persist in large numbers for several weeks. Because of these long-term outages, city residents expressed concern about the fact that many citizens had limited to no access to essential services such as fresh food, dry shelter, or medical services for days after major storms. Furthermore, different parts of the city experience the storm differently, and some areas have residents who are far less mobile and less able to travel to different areas that might have the power needed to provide key services.

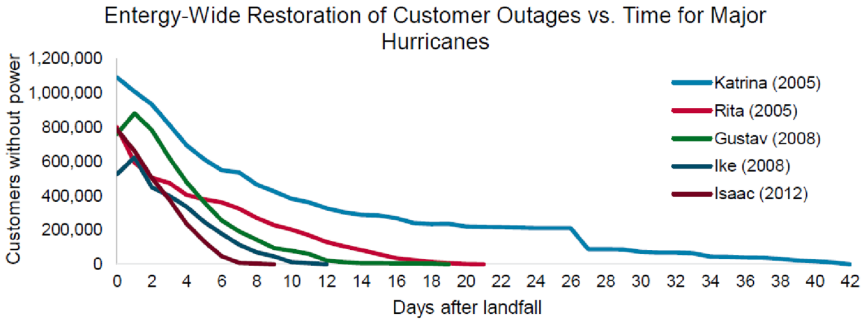

Figure 1: Evolution of electricity outages following the landfall of recent major storms in New Orleans.

Table 1: Critical infrastructure supporting the community.

Infrastructure Facility Types Considered for Grid Modernization Support	
911 System	**Medical Services**
911-Supporting Wire Centers	Hospitals
Public Safety Answering Point	Air Ambulance
City Emergency Support	Medical Centers
Emergency Operations Center (EOC)	Dialysis Centers
Evacuation Pickup Sites	**Provisions**
Task Force Sites	Pharmacies
Points of Distribution (PODs)	Gas Stations
Fire Stations	Grocery Stores
Police Stations	Bank Main Offices
NOLA City Fuel Storage	Bank Branches
Shelter	**Water and Wastewater**
Shelters - City Assisted Sheltering Plan (CASP)	Sewer Pump Stations
Potential Shelters - Non-CASP	Drainage Pump Stations
Hotels	Water Purification Facilities
	Sewer Treatment Plants

To make New Orleans more resilient in the face of major hurricanes, city stakeholders selected a goal focused on creating sustained and equitable access to essential services enabled by electric power. The city took two steps to understand this. First, they catalogued critical infrastructure across the city. Table 1 lists the locations they considered. Second, officials examined how these facilities were distributed across the city. To ensure equitable access, they broke the city into seven zones as shown in Figure 2. They then determined which infrastructure locations were likely to be

inundated by flood waters during a worst-case storm event. In this case, a worst-case event was assumed to be an event with flooding as disastrous as Hurricane Katrina. The bar graph on the right side of Figure 2 lists the facilities in each category in Zone 1. Facilities marked in blue are those that are likely to be inundated by flood waters, and those marked in green are likely to be untouched by flooding. It is these facilities (marked green) that are key targets for grid modernization.

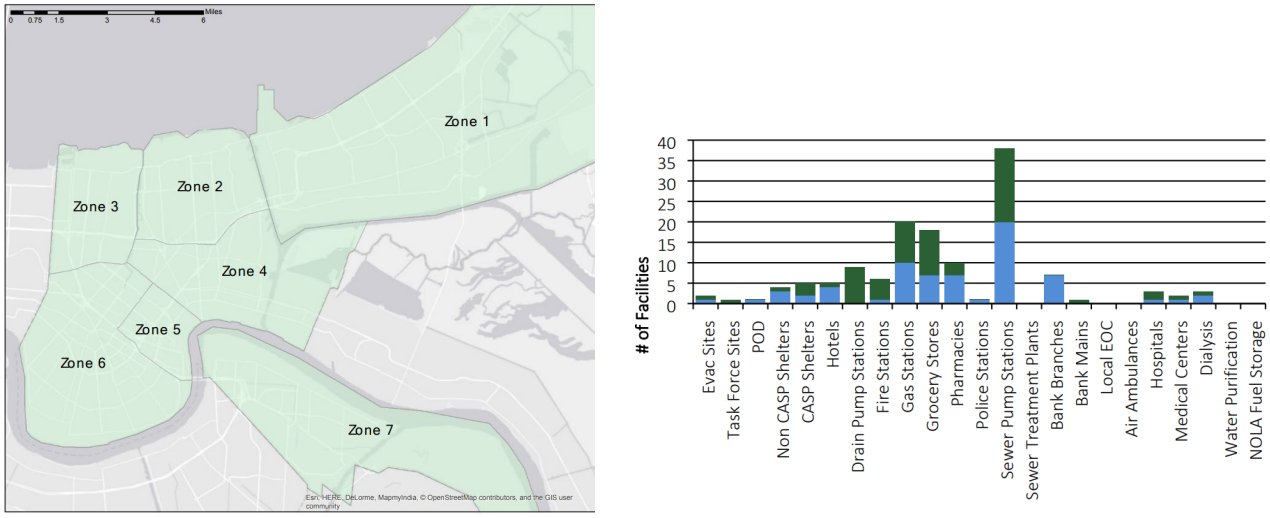

Figure 2: The seven zones created for the city (left) and the distribution of critical infrastructure in Zone 1 (right). Note that the blue bars indicate infrastructure in areas likely to be inundated by flood waters, and the green bars represent infrastructure in areas likely to be spared.

Armed with the information indicated above, the city decided to create a metric that could quantify its goal to provide sustained and equitable access to key community facilities after a storm. In this case, the city elected to maximize the percentage of key facilities that would have on-site electric power for at least 7 days after a major storm event.

The city used its metric to evaluate the cost effectiveness of three different sets of options for achieving its goal. The three options included the following:

- Microgrids: Grid-tied distributed energy resources that could serve a collection of buildings and operate in an islanded mode after a storm.
- Distribution hardening: Undergrounding and distribution automation.
- Local backup generation (i.e. building-tied generators)

Ultimately, the city selected a collection of resilience nodes distributed throughout the city that could be served by small microgrids. Figure 3 shows the percentage of all key infrastructure locations that could be served by these resilience nodes. Figure 4 shows that only a smaller portion could be served in Zone 1, which has a poor population and significant flooding risk. Most importantly, however, the city was able to provide power for key facilities providing food, dry shelter, and medical care. New Orleans has not yet

implemented the proposed solutions for achieving resiliency. Further information on the case study can be found in Reference [1].

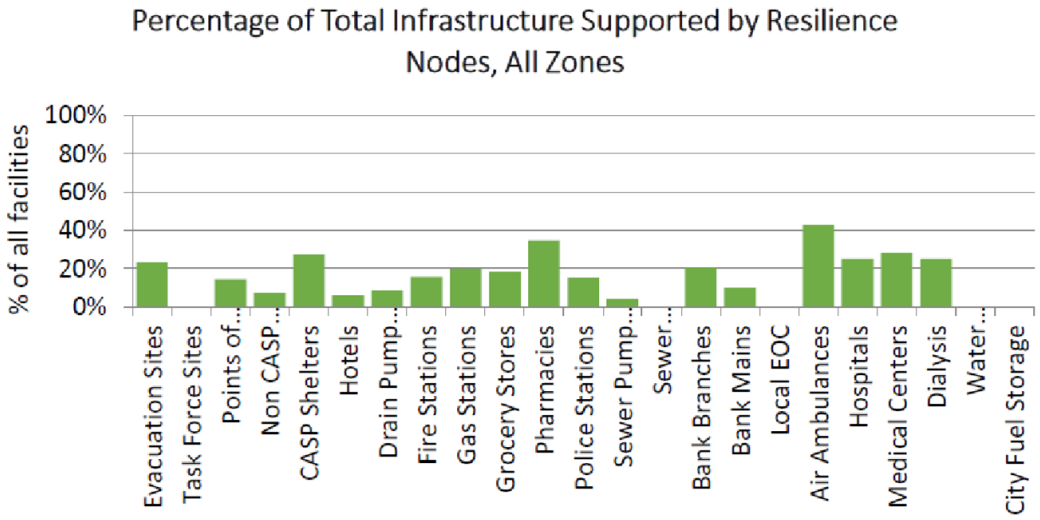

Figure 3: City-wide percentage of key infrastructure facilities supported by resilience nodes.

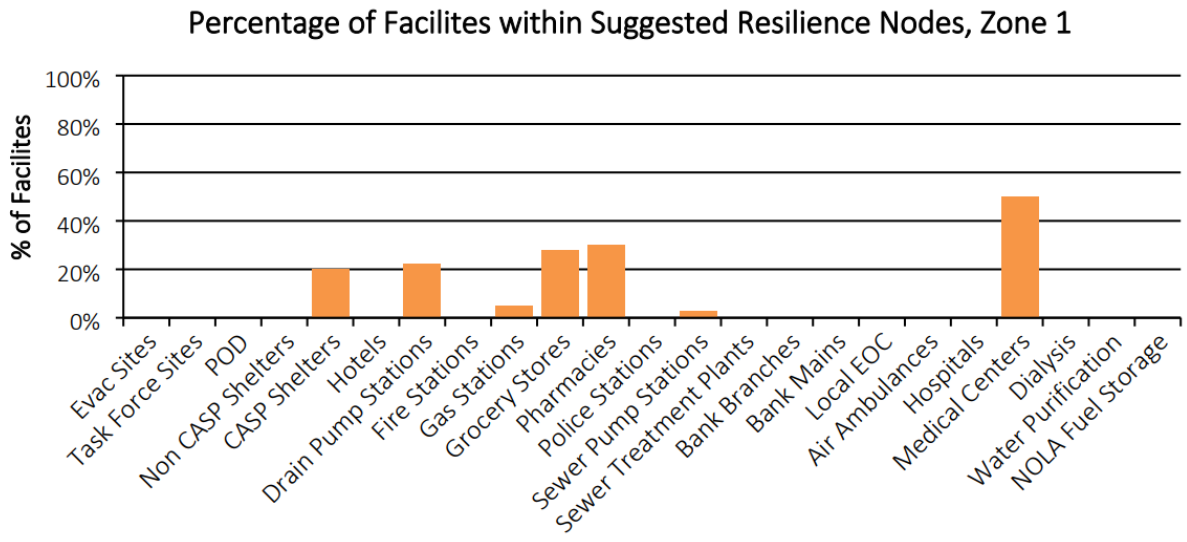

Figure 4: Percentage of key facilities in Zone 1 that can be supported by resilience nodes.

[1] R. Jeffers et al. "A Grid Modernization Approach for Community Resilience: Application to New Orleans, LA." Sandia National Laboratory, Technical Report SAND-2017-11959, October 1, 2017. https://www.osti.gov/servlets/purl/1510648