GRID MODERNIZATION INITIATIVE
U.S. Department of Energy

Category 1 (Foundational/Regional) Project Final Report

Report Completion Date:

Section 1: Project Information

Project Information	
Control #: Title:	
Project Title:	Grid Analysis and Design for Energy and Infrastructure Resiliency
Project PI Name and Lab Affiliation: Project Co-PI (plus-one) and Lab Affiliation:	PI: Robert F. Jeffers, SNL, rfjeffe@sandia.gov +1: Mary Ewers, LANL, mewers@lanl.gov
DOE Project Manager(s):	Stewart Cedres, stewart.cedres@hq.doe.gov
Period of Performance:	April 1, 2016 – March 15, 2017
Date Closed:	

Section 2: Project Assessment and Checklist

Project Assessment and Checklist	Y/N	Confirmation Date	Comments
Have all quarterly reports been submitted?	**Y**		
Have all milestones have been delivered?	**Y**		
Are all products finalized (e.g. technical reports, journal articles)?	**N**		Report on Transactive Controls Feasibility remains DRAFT – Delivered Jan 2017 to DOE. Primary technical summary report remains OUO-DRAFT (at direction from City of New Orleans). Released additional shorter unlimited release report in April 2017
Have all project products been finalized and presented/submitted to DOE Project Manager(s) and/or GMI Leadership?	**Y**		
Have all potential sensitivities been identified and addressed with DOE Project Managers and/or GMI Leadership?	**Y**		
Has the project team received feedback from Project Stakeholders (e.g. advisory group)?	**Y**		This project had extensive interaction

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			with city and electric utility stakeholders on all deliverables.
Are there any open or pending costs?	**N**		

Section 3: Outcomes, Deliverables, Publications

Provide the following:
**In addition to titles, provide links to any websites or other repositories where deliverables and/or other information will be available after the project has been completed*
**Publications available for public release, URLs, etc. listed here should be uploaded to GMLC Open Point*

For the purpose of this section, the following entities will be summarized as "New Orleans Stakeholders": Entergy New Orleans, City of New Orleans – Office of Resilience & Sustainability, City of New Orleans – Homeland Security & Emergency Preparedness, The Sewerage and Water Board of New Orleans, The 100 Resilient Cities organization.

1. **List of Outcomes:**
   - New Orleans Stakeholders were provided a mechanistic analysis of cascading multi-infrastructure outages driven by hurricanes and major storms, focused on how these outages would impact the ability of the city to provide basic human needs to the population.
   - A new tool was developed by Sandia – the Resilience Node Cluster Analysis Tool (ReNCAT) – which aids analysts in finding clusters of lifeline-providing infrastructures conducive to microgrid development.
   - New Orleans Stakeholders were provided an analysis of resilience investment alternatives for the power system which would most cost-effectively improve community performance during major grid outages.
   - New Orleans Stakeholders improved their alignment with each other on strategies to achieve improved community resilience through grid investments.
   - Lessons learned were shared among the broader 100 Resilient Cities community.
2. **List of Deliverables:**
   a. **Task 1: Infrastructure Resilience Analysis**
      i. Final Official Use Only Report delivered to DOE and New Orleans Stakeholders
   b. **Task 2: Grid Enhancement Design options and Cost/Benefit**
      i. Final DRAFT Official Use Only Report delivered
      ii. Final Open Access report delivered and published
   c. **Task 3: Transactive Controls Feasibility Analysis**
      i. Final DRAFT report delivered to DOE and New Orleans Stakeholders (not released due to feedback from stakeholders)
3. **List of Publications:**

a. Jeffers, R., Brodsky, N., Hightower, M., Baca, M., Ewers, M., Wachtel, A., Kelic, A., Aamir, M., Flanagan, T., Bynum, L., Peplinski, W., Corbet, T., Ambrosiano, J., Tassef, B., Linger, S., Crawford, T., Pasqualini, D., Arnold, J., Fogeman, W., and Walsh, S. (2016) **New Orleans Resilience Analysis: Infrastructure Analysis Overview.** Sandia National Laboratories. Official Use Only.
b. Jeffers, R., Hightower, M., Brodsky, N., Baca, M., Wachtel, A., Walsh, S., Aamir, M., Gibson, J., Fogleman, W., Peplinski, W., Ewers, M., Pasqualini, D., and Ambrosiano, J. (2017) **DRAFT Grid Modernization for Community Resilience in New Orleans, LA.** Sandia National Laboratories. Official Use Only.
c. Jeffers, R., Hightower, M., Brodsky, N., Baca, M., Wachtel, A., Walsh, S., Aamir, M., Gibson, J., Fogleman, W., Peplinski, Vugrin, E., W., Ewers, M., Pasqualini, D., and Ambrosiano, J. (2017) **A Grid Modernization Approach for Community Resilience: Application to New Orleans, LA.** Sandia National Laboratories. SAND2017-11959.
d. Jeffers, R., Walsh, S., Baca, M., Hightower, M. (2017) **DRAFT Feasibility of Transactive Energy Scheme for New Orleans, LA.** Sandia National Laboratories.

4. **List of Awards or Recognition:**
   - Official letter of gratitude addressed to Stewart Cedres and Gilbert Bindewald from the Chief Administrative Officer of the City of New Orleans (April 17, 2017)
5. **List any ROIs – Software, Intellectual Property, Licensing, Patents, Etc.**
   a. Resilience Node Cluster Analysis Tool (ReNCAT) v.1.0. Not Released for Public Use.
      i. NOTE: ReNCAT v1.1 has been released as open use software under the Puerto Rico Multi-Lab project.

Section 4: Final Costing

Each Lab Financial POC Completes Final Costing of GMLC Projects for their lab. PIs, Lab Leads will need to assist but not required to report financials with this final report.

Section 5: Final Thoughts/Comments

Final Thoughts	Comments
Lessons Learned	**One of the major contributions of this project was a shift in thinking for city and utility planners, along two dimensions:** 1. **Worst-consequence as opposed to worst-case.** Plan to minimize negative consequences to society, which may not occur during the worst-case event

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	(due to other mitigating factors such as evacuation) 2. **City + Utility Integration.** Explicit understanding of intersection between metrics used to gauge community resilience and those used to gauge electric utility resilience. **The resilience node approach was fleshed out from concept to application. We learned:** 1. At the time of completion of this project, the state of the art was not mature enough to calculate resilience metrics describing the performance of communities during major disruptions. Several gaps are mentioned in the final report. 2. Despite this limitation, using "proxy" metrics (see report) for community performance was enough to align interest in resilience nodes as a concept between Entergy and the City of New Orleans. Furthermore, the process used enabled specification of a portfolio of 22 microgrid locations (including buildings) that, to a reasonable level of confidence, achieve improvement in community resilience. 3. At least in New Orleans, planners are willing to discuss the prioritization of critical load. This prioritization can be nuanced and based on the specific needs of different communities throughout the city. This type of prioritization should be useful for planners beyond this project. 4. Even with New Orleans – a city with major resilience challenges relative to the median – the tradeoff between providing resilient energy service to residential buildings versus critical

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	lifeline services – while conceptually simple – is politically challenging. 5. Developing a business model that efficiently allows recovery of resilience investment by the utility (or a 3rd party microgrid provider) is what may limit investment in resilience nodes that power diverse privately-owned assets.
Opportunities for Improvement	**Although the researchers specify a performance-based, consequence-focused resilience metric, they were not able to calculate it to the level of confidence necessary for investment planning, thereby having to resort to "proxy" metrics.** **The project team attempted, yet were unable to calculate forward-looking, major-event-inclusive outage characteristics (frequency and duration) at the distribution feeder level. Partially this was limited by access to outage data, but also limited by tool sophistication.** **Because of the previously mentioned limitations, the portfolios discussed do not explicitly account for the opportunity to conduct blackstart using a system of microgrids.** **The microgrid alternatives discussed do not explicitly account for various "blue sky" value streams, such as the ability to integrate renewables or to decrease the overall cost of service for Entergy.**
Future Projects: Ideas for future work? Possible next steps and research direction?	**At the time of this final closeout, one follow-on project has been completed focused on New Orleans. This project developed conceptual designs for two microgrid-based resilience nodes that explicitly balanced three performance**

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	dimensions: resilience, sustainability, and affordability/efficiency. **This planning process (portfolio development focused on resilience alone, conceptual designs focused on three dimensions) could be greatly improved. All three dimensions should be included in the portfolio development stage. We may refer to this as a resilience-inclusive, DER-inclusive capacity expansion process.** **Thermal systems and opportunities for demand-side management/planning can be better integrated into the Resilient Community Design (formerly: Urban Resilience Planning) Process.** **Community planning variables, such as zoning and building standards, should be better integrated as a decision variable in the Resilient Community Design process.** **We should better understand the ability and need of the insurance industry to understand the benefits of resilience nodes.**
Other:	**Beyond being an intellectually interesting and challenging project, the ability to improve community wellbeing in a place as culturally valuable as New Orleans has been incredibly rewarding. - Robert Jeffers**