Sandia National Laboratories

Energy Storage for Resilience Applications

PRESENTED BY

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Outline

Acknowledgements

Reliability versus Resilience

Quantifying the Resilience Benefit

Designing the System for Resilience

Monetizing the Resilience Benefit

Co-optimizing Resilience and Reliability

Summary

Acknowledgements

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- The DOE Energy Storage Program managed by Dr. Imre Gyuk of the DOE Office of Electricity
- The DOE Microgrid Program managed by Mr. Dan Ton of the DOE Office of Electricity
- The DOE Puerto Rico Program managed by Mr. Dan Ton and Dr. Stephen Walls of the DOE Office of Electricity

Reliability versus Resilience

Reliability – Low consequence high probability

- Squirrels, birds, etc.
- Traffic accidents
- Trees/wind
- Lightning




Resilience - High consequence low probability events

- Severe winter storms
- Hurricanes
- Tornados
- Earthquakes
- EMPs and GMDs
- Fires
- Physical or cyber attack




Reliability versus Resilience

Reliability

Defined as the ability of the power system to deliver electricity in the quantity and with the quality demanded by users. Reliability is generally measured by interruption indices defined by the Institute of Electrical and Electronics Engineers (IEEE) Standard 1366.

Metrics are well defined

- System Average Interruption Duration Index (SAIDI)
- System Average Interruption Frequency Index (SAIFI)

Utilities are compensated based on reliability performance

Resilience

Presidential Policy Directive 21 definition:

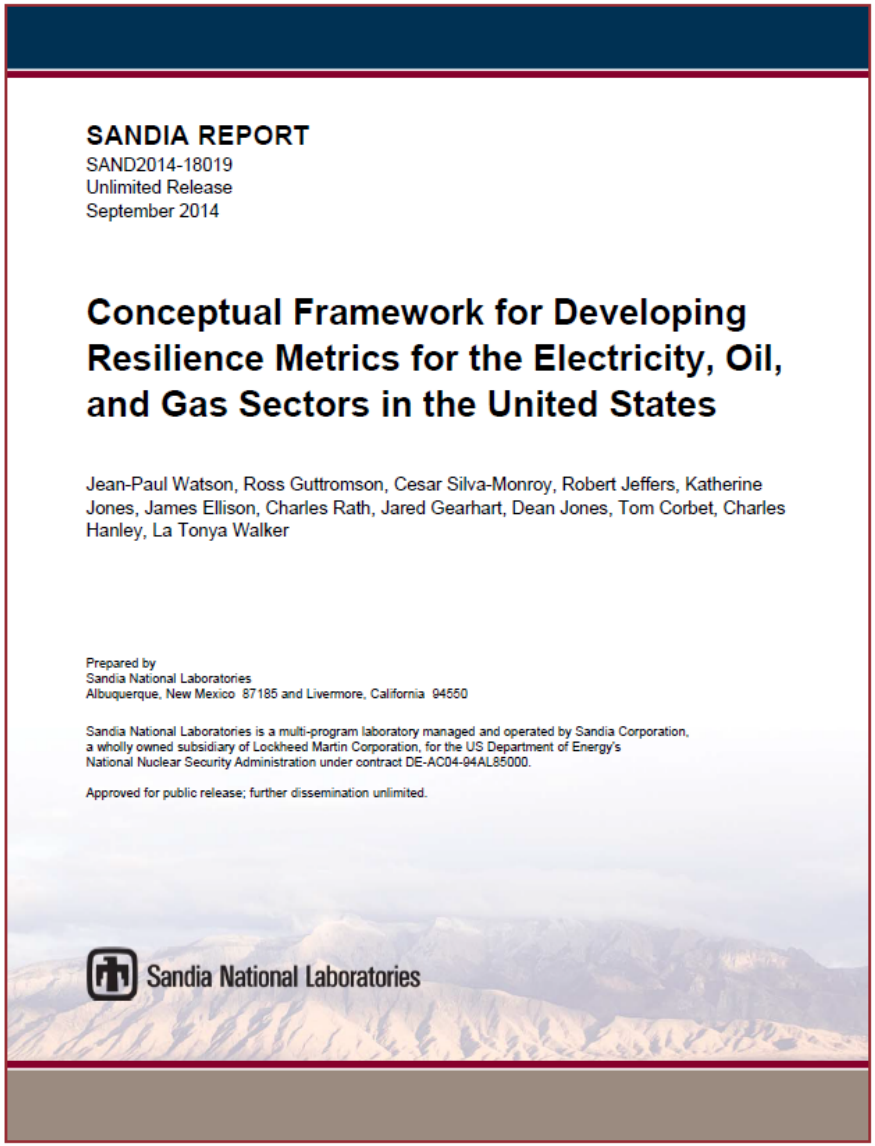
The term "resilience" means the ability to **prepare for and adapt** to changing conditions and **withstand and recover rapidly** from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.

"Standard" metrics do no exist

- GMLC metrics project
- Sandia metrics research

Compensation?

Resilience Metrics



SANDIA REPORT
SAND2014-18019
Unlimited Release
September 2014

Conceptual Framework for Developing Resilience Metrics for the Electricity, Oil, and Gas Sectors in the United States

Jean-Paul Watson, Ross Guttromson, Cesar Silva-Monroy, Robert Jeffers, Katherine Jones, James Ellison, Charles Rath, Jared Gearhart, Dean Jones, Tom Corbet, Charles Hanley, La Tonya Walker

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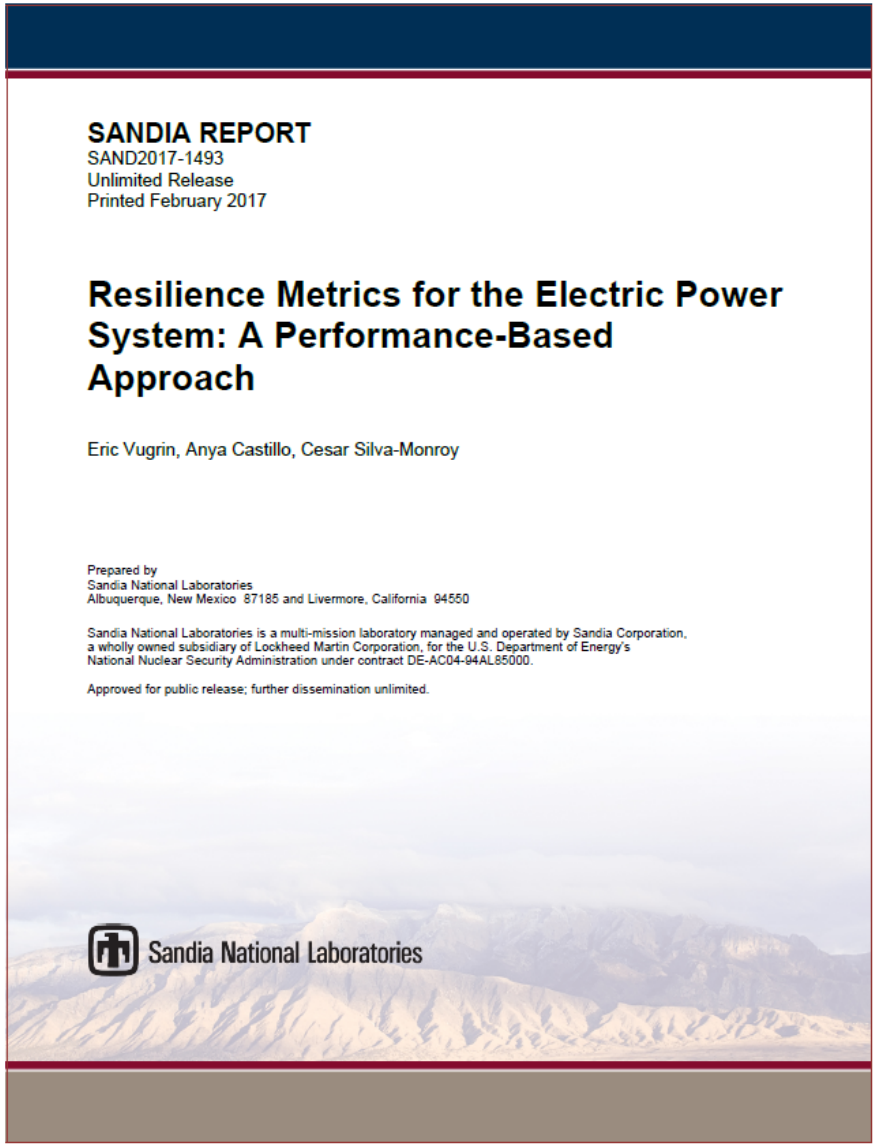

SANDIA REPORT
SAND2017-1493
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Printed February 2017

Resilience Metrics for the Electric Power System: A Performance-Based Approach

Eric Vugrin, Anya Castillo, Cesar Silva-Monroy

Prepared by
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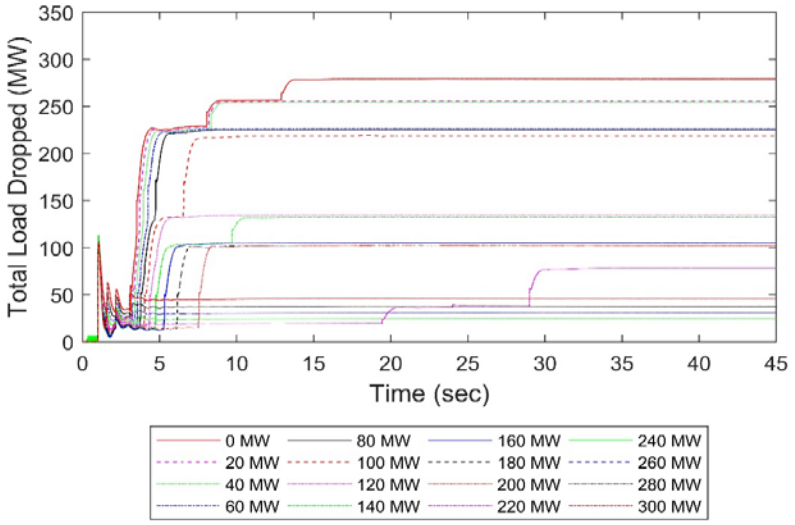
Resilience Opportunities for Energy Storage

Stand Alone Applications

- Grid stability
  - Voltage stability
  - Transient stability
  - Small signal stability
- Spinning reserve
- Frequency regulation
- Backup power



Puerto Rico Load Shedding Analysis

Microgrids

- Energy storage is a key component of any microgrid

Challenges:

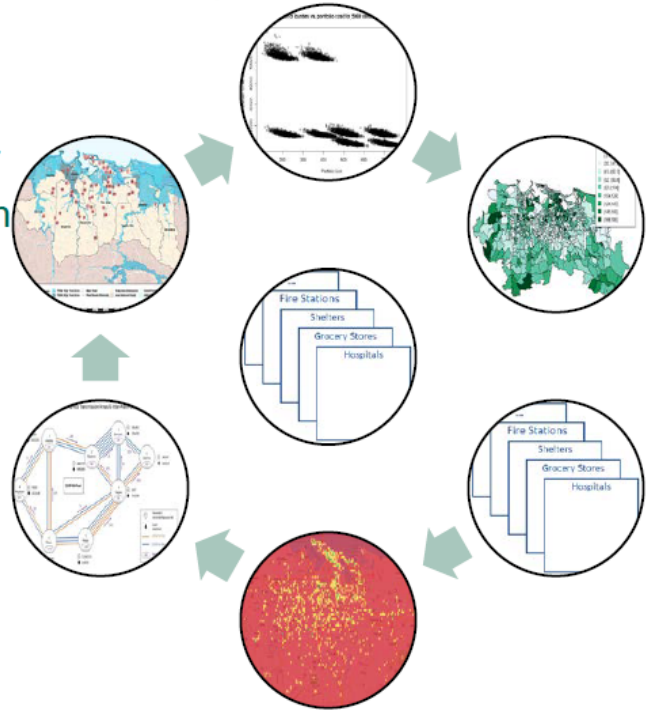
- Identifying the appropriate resilience metrics
- Monetizing the benefits
- Tools for resilience analysis
- Tools for microgrid design
- Obtaining data

Sandia Resilience Analysis Process - Microgrids

5. Calculate burden, service level, and cost metrics

4. Define portfolio options inclusive of technology selection for each microgrid

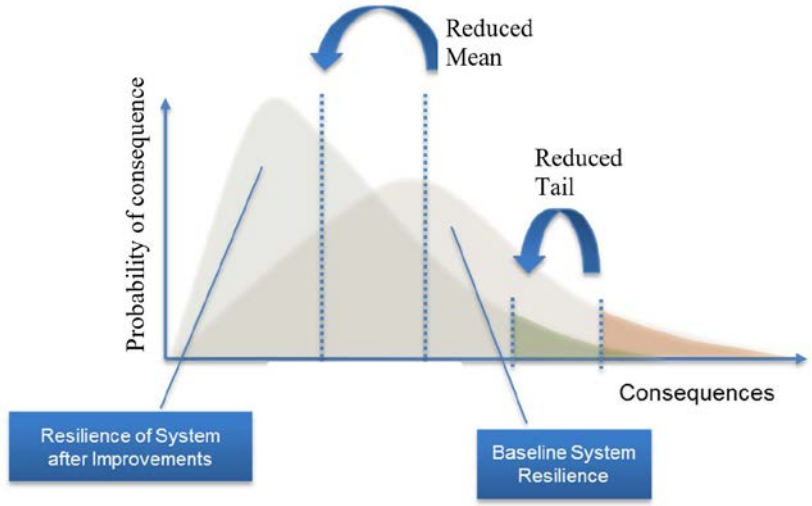
6. Visualize metrics and resiliency options



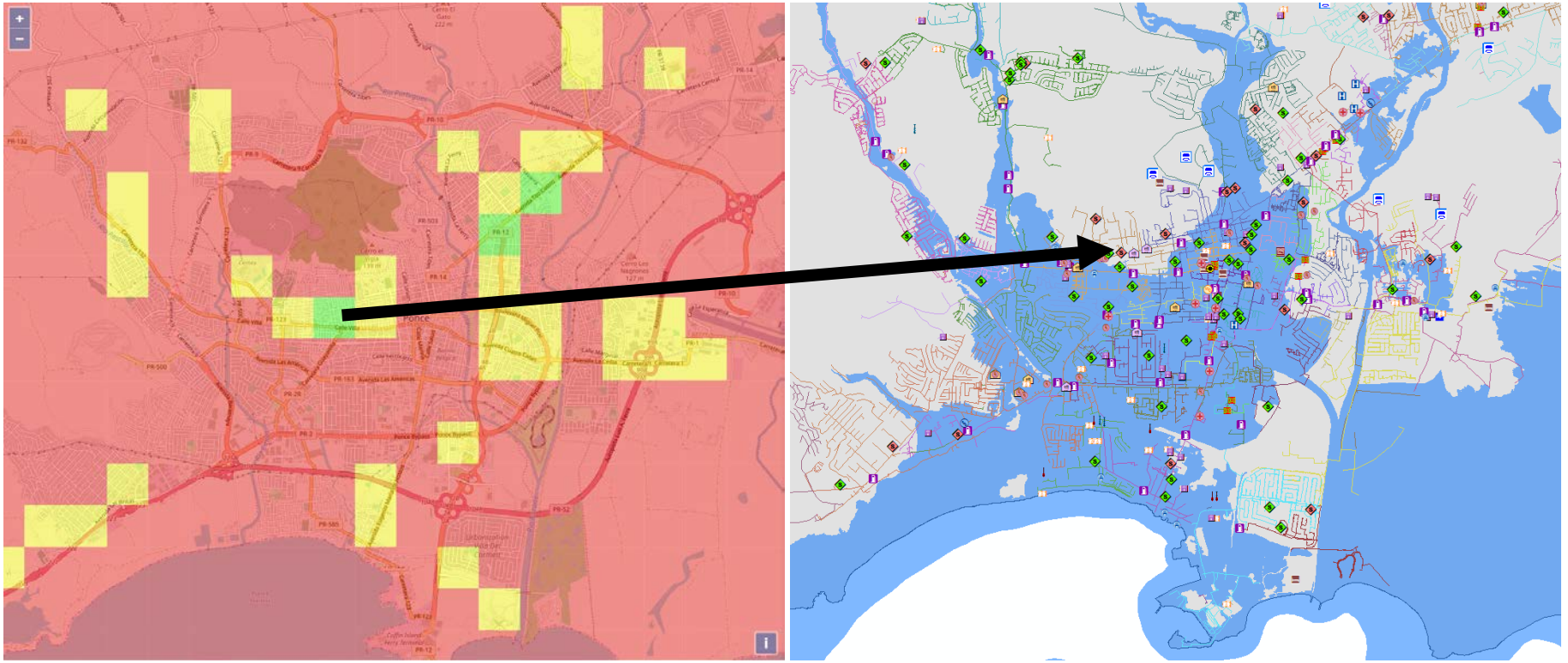
3. Microgrid service areas informed by existing grid topology

1. Obtain data for all critical infrastructure sectors

2. Run ReNCAT to determine locations providing high service levels



Puerto Rico Microgrid Analysis Example



Green squares identify high concentrations of critical services outside of the hazard zones

Threats considered: flooding, landslides, earthquakes

Sterling Municipal Light Department Resilience Example

Sterling Potential value streams:

- Energy arbitrage
- Reduction in monthly network load (based on monthly peak hour)
- Reduction in capacity payments (based on annual peak hour)
- Grid resilience
- Frequency Regulation

Grid Resilience was the primary goal – other applications help pay for the system

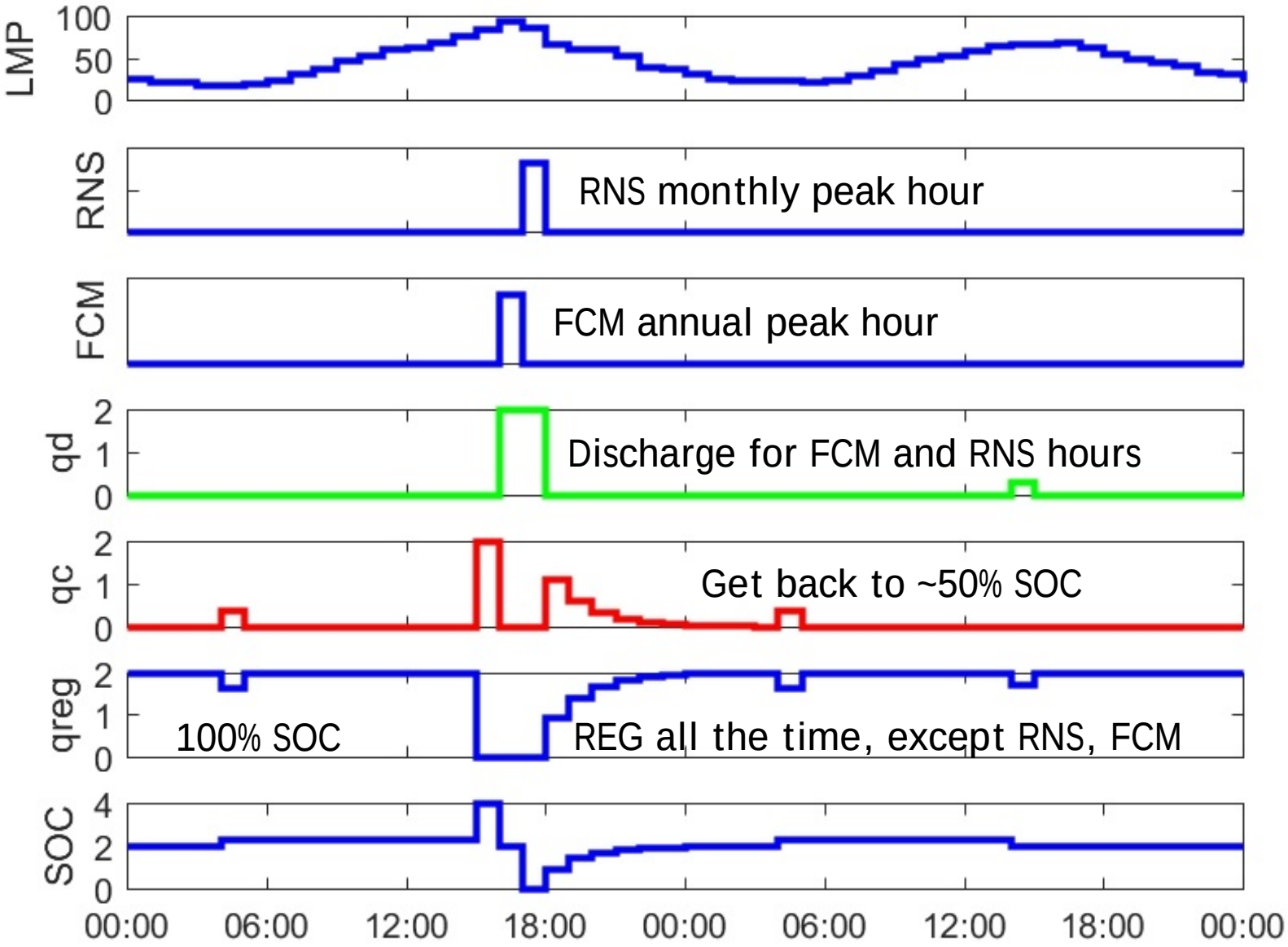
Several potential value streams (1MW, 1MWh 2017-18 data)

Description	Total	Percent
Arbitrage	$40,738	16.0%
RNS payment	$98,707	38.7%
FCM obligation*	$115,572	45.3%
Total	$255,017	100%

For more information, please refer to:

R. H. Byrne, S. Hamilton, D. R. Borneo, T. Olinsky-Paul, and I. Gyuk, "The value proposition for energy storage at the Sterling Municipal Light Department," proceedings of the 2017 IEEE Power and Energy Society General Meeting, Chicago, IL, July 16-20, 2017, pp. 1-5. DOI: 10.1109/PESGM.2017.8274631

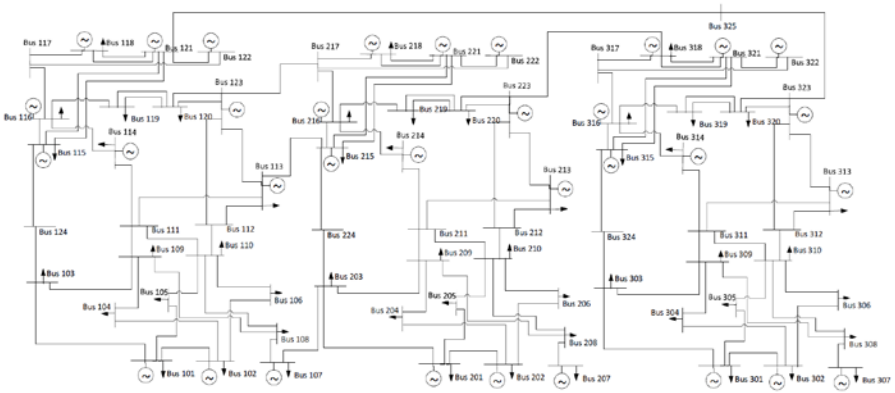
Sterling Municipal Light Department Resilience Example



Co-Optimizing Resilience and Reliability

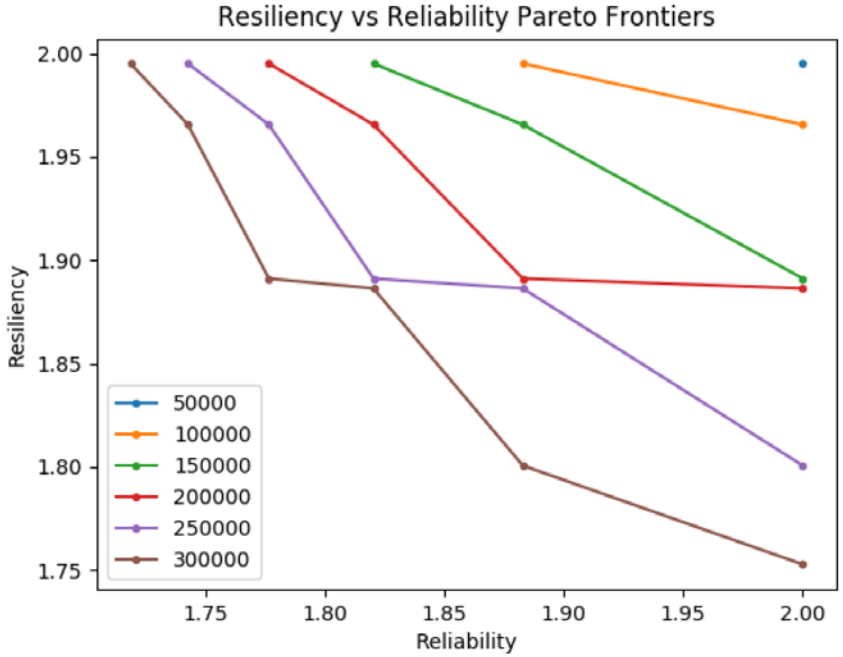
Investment options considered:

- Insert an additional fuse
- Replace a fuse with a recloser
- Place a short distribution line underground
- Add squirrel guard or bird spikes/reflector
- Add an auto barrier
- Increase spending on media outreach



- Formulated as a two-stage stochastic optimization problem

Results for the IEEE RTS-96 System



B. J. Pierre, B. Arguello, "Co-Optimization to Integrate Power System Reliability Decisions with Resiliency Decisions," Sandia National Laboratories, Technical Report SAND2018-12535, September 2018.

Summary

Energy storage is a critical asset for improving grid reliability and resilience

Reliability is well defined and compensation methods are in place for some applications

- Ancillary services: frequency regulation, reserve products
- Utility compensation based on reliability metrics
- Additional work is required to improve the regulatory framework and market products

Resilience

- Metrics are not well defined or agreed upon – system design is heavily influenced by the definition of resilience
- Monetizing resilience benefit is difficult
  - Blue sky benefits
  - Resilience benefits
  - Valuation of resilience (e.g., Value of Lost Load – VOLL)
- Design tools for resilience analysis and design are in their infancy
- Significant work is required to improve the regulatory framework and market products

Additional information: www.sandia.gov/ess