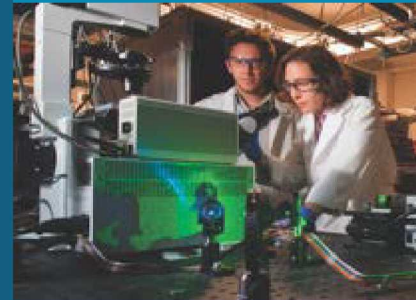


# Grid Reliability and Resilience – Opportunities for Energy Storage



PRESENTED BY

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## Outline

Acknowledgements

Reliability versus Resilience

Opportunities for Energy Storage

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 – 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

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 not exist

- GMLC metrics project
- Sandia metrics research

Compensation?





**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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Approved for public release; further dissemination unlimited.



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**SANDIA REPORT**

SAND2017-1493  
Unlimited Release  
Printed February 2017

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

Eric Vugrin, Anya Castillo, Cesar Silva-Monroy

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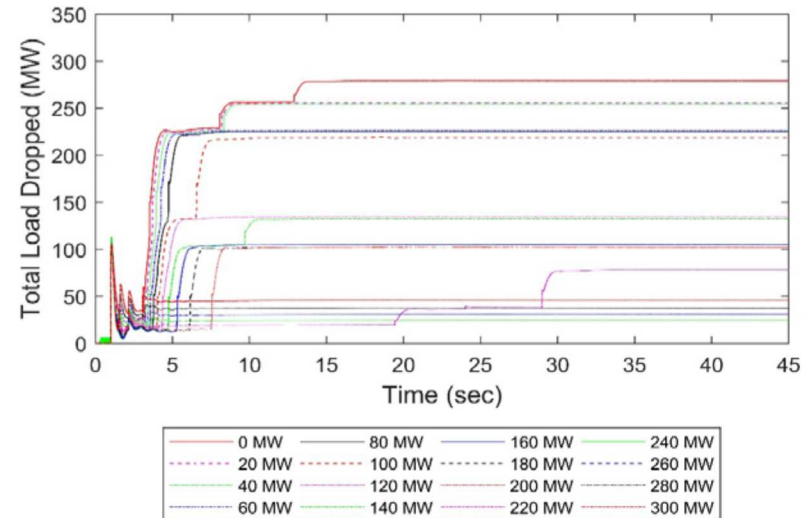


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## Stand Alone Applications

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



Puerto Rico Load Shedding Analysis

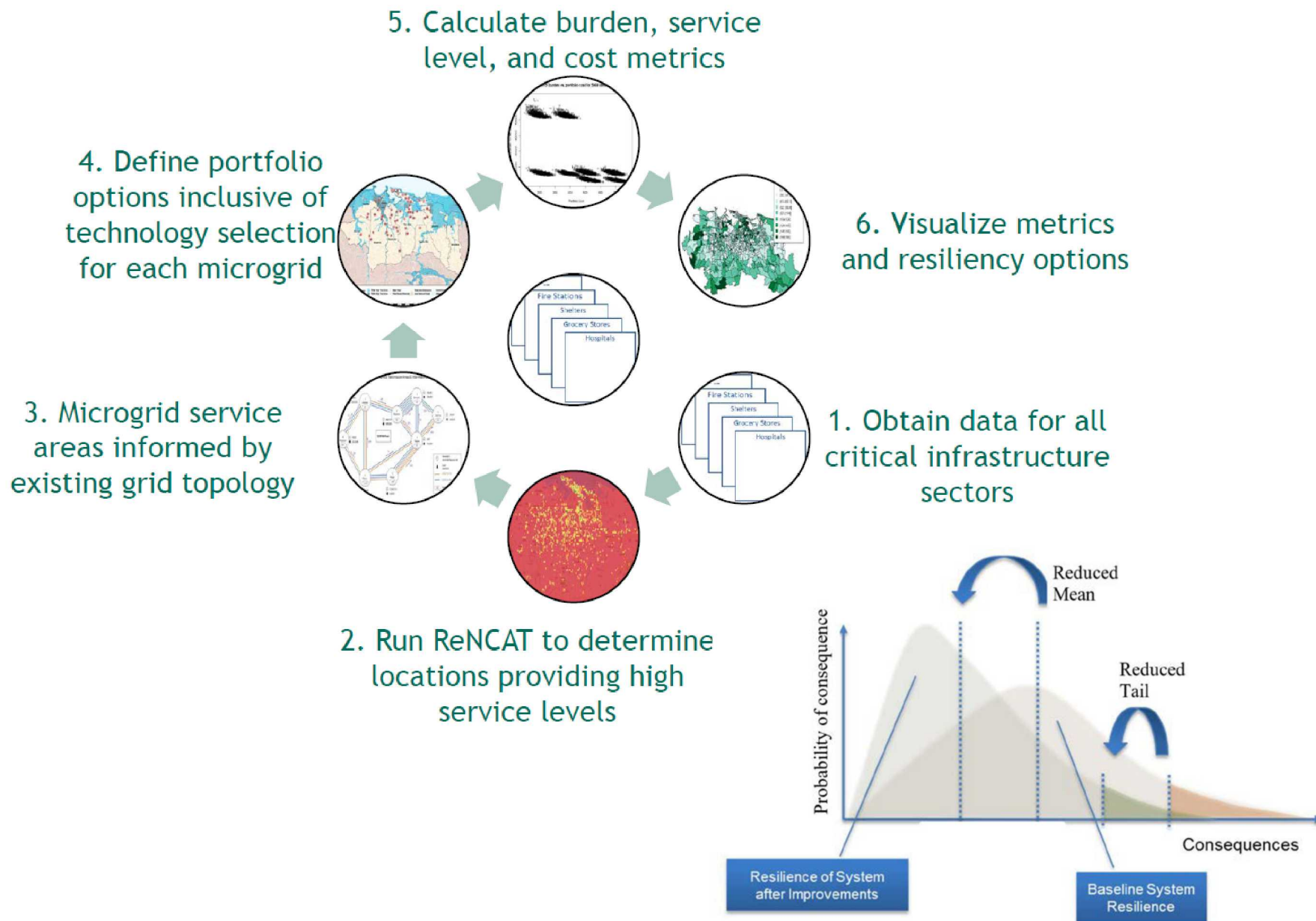
## Microgrids

- Energy storage is a key component of any microgrid

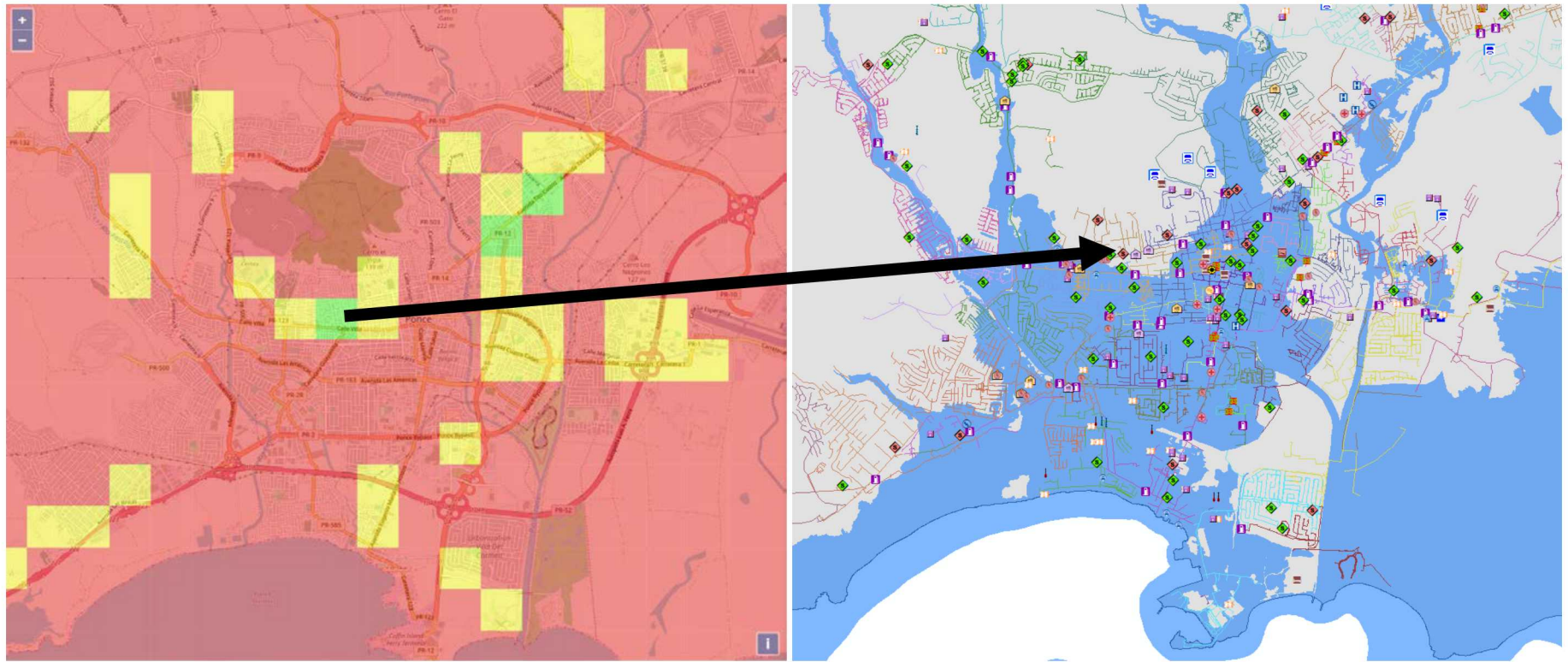
## Challenges:

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









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



## Summary



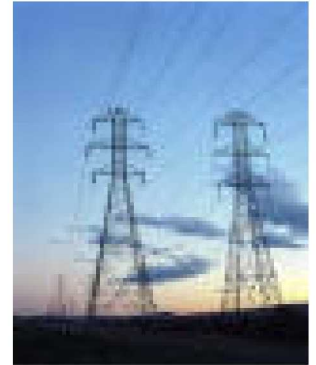
Energy storage is a critical asset for improving grid reliability and resilience

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
- 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](http://www.sandia.gov/ess)