Sandia National Laboratories

A SUNNY RESILIENT ENERGY FUTURE

PRESENTED BY

Robert Broderick

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U.S. DEPARTMENT OF ENERGY | NNSA

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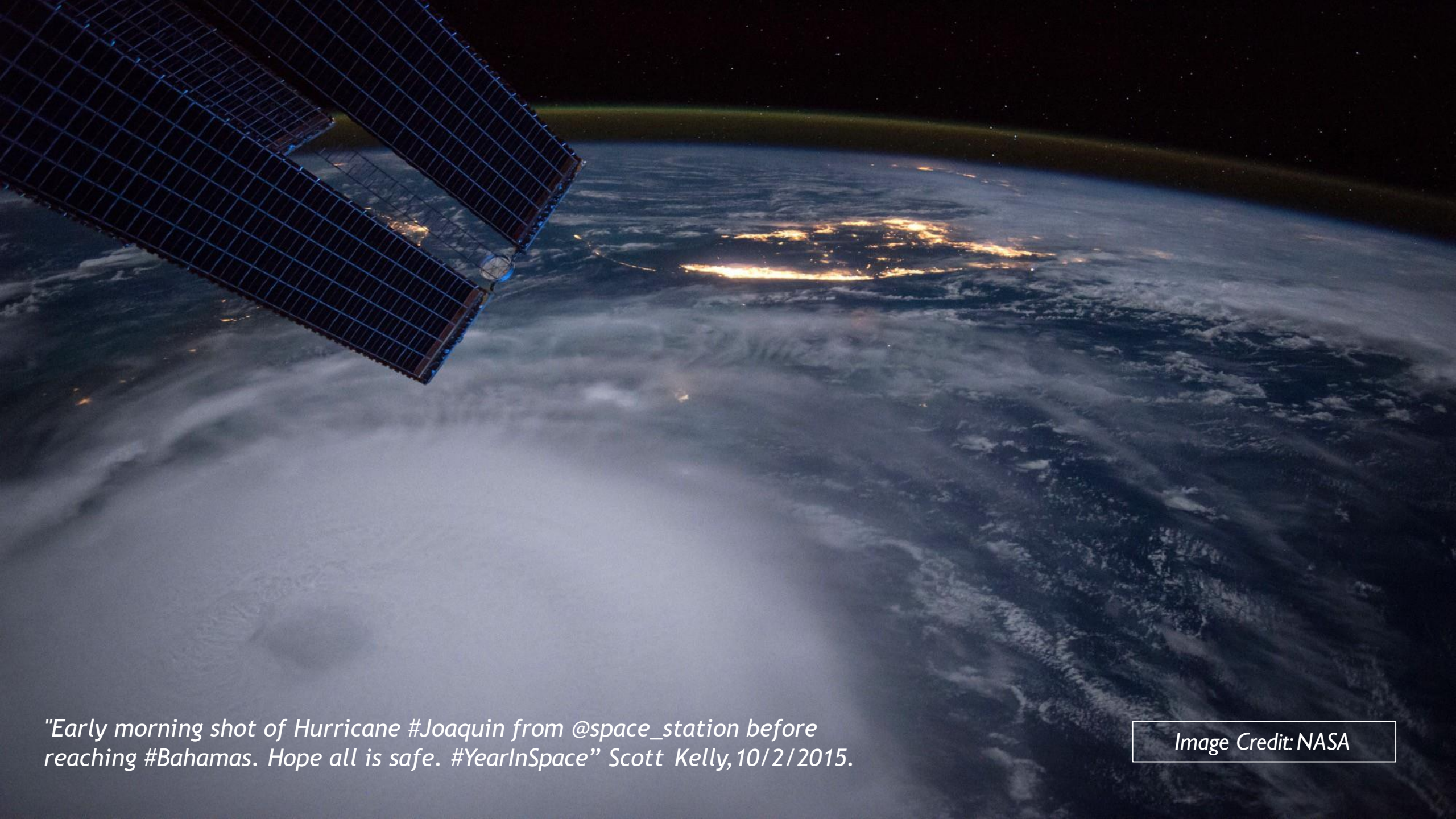


"Early morning shot of Hurricane #Joaquin from @space_station before reaching #Bahamas. Hope all is safe. #YearInSpace" Scott Kelly, 10/2/2015.

Image Credit: NASA


ENERGIA SOLAR DE CALIFORNIA
ELECTRIFICACION DE CERCOS
ILUMINACION Y
SISTEMA DE BOMBEO

PV deployment has come a long way…

…but none of these systems work during a grid outage!

PV Eras

We are here, and solar is ready to play major role.

Flexible demand and storage enable a solar powered future

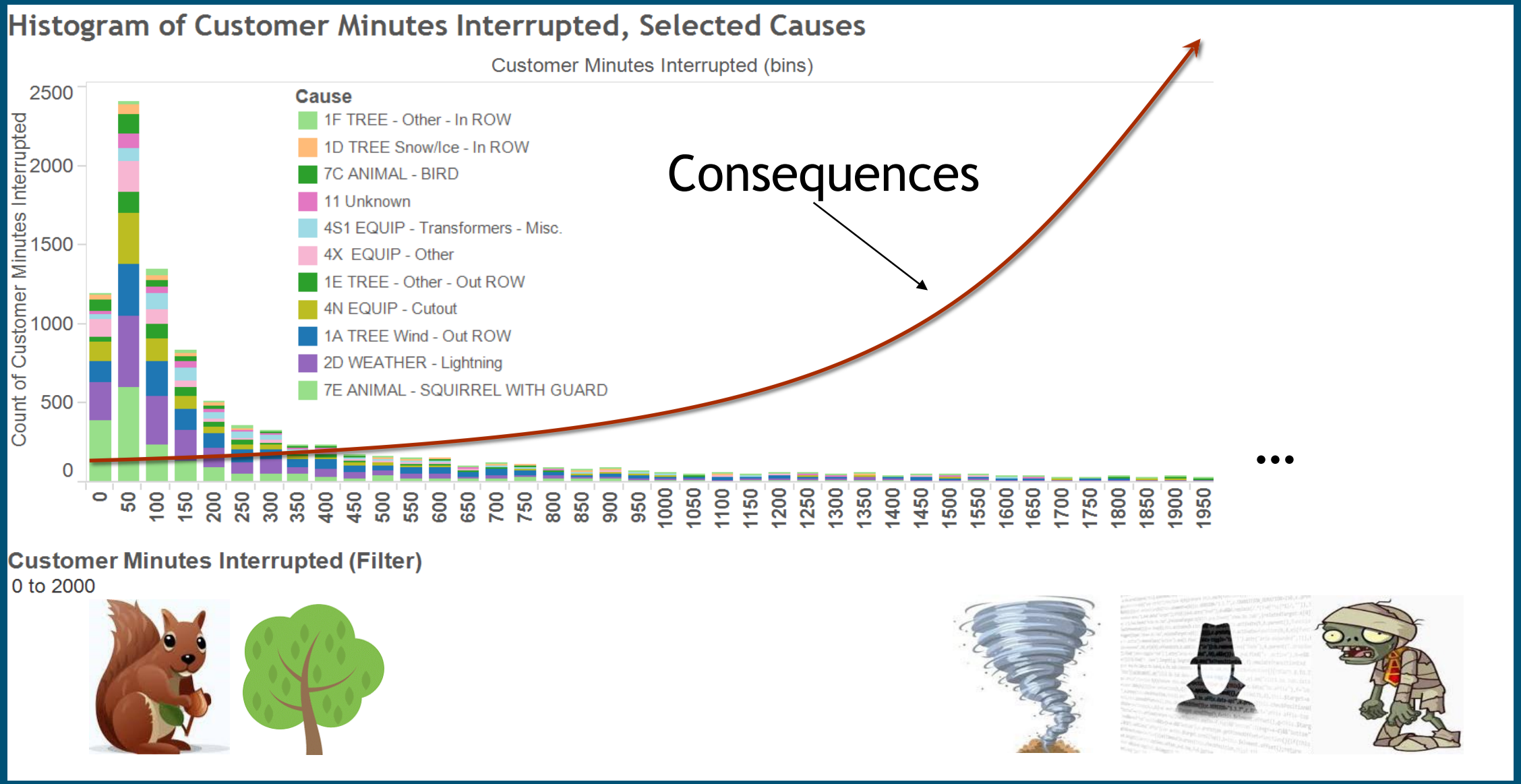
RELIABILITY

99.97%

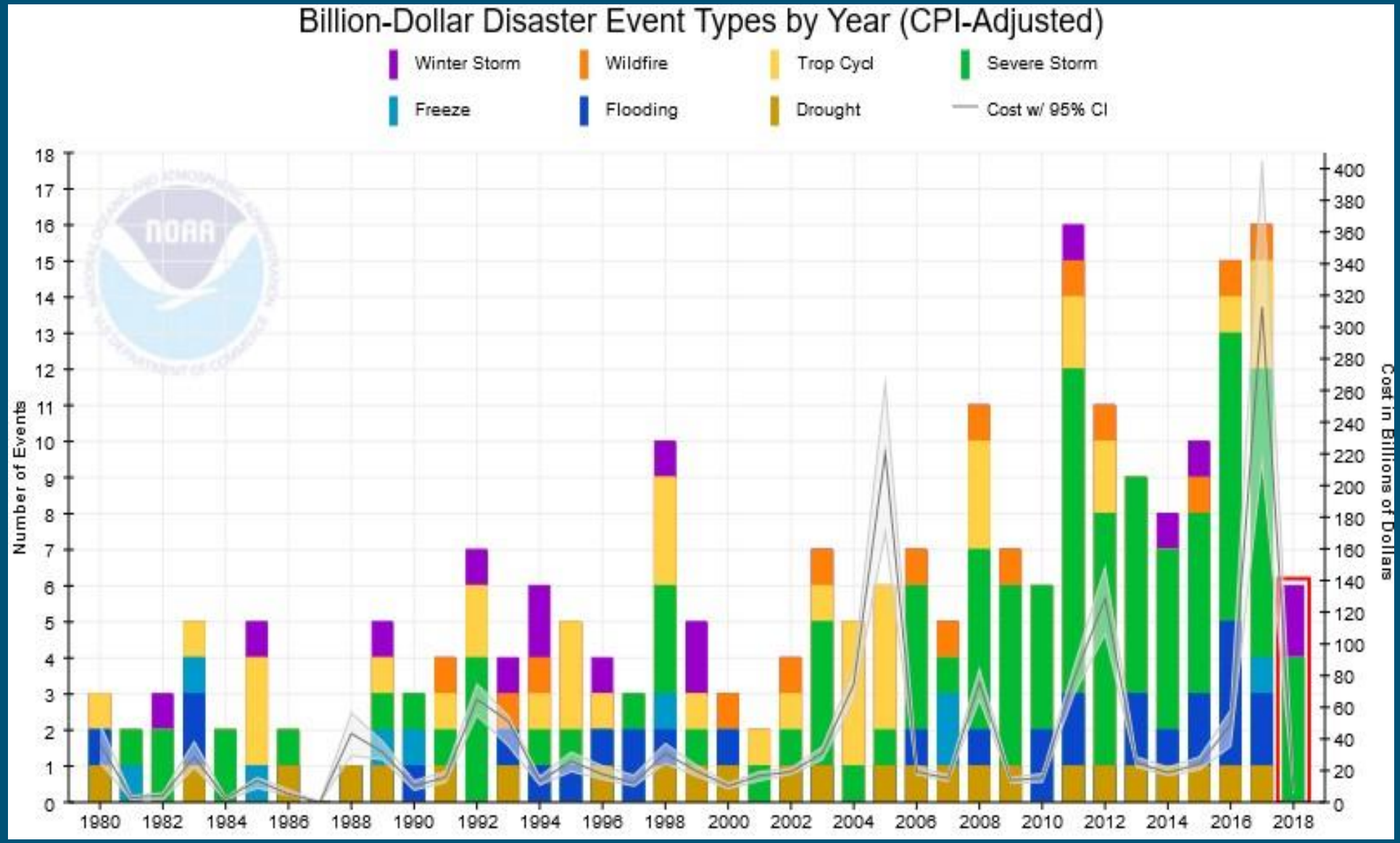
What would it cost add another "9" of reliability?


HESS

Reliability focuses on average system performance, skips large-scale events, and does not consider consequences…



Large-scale events becoming more frequent…



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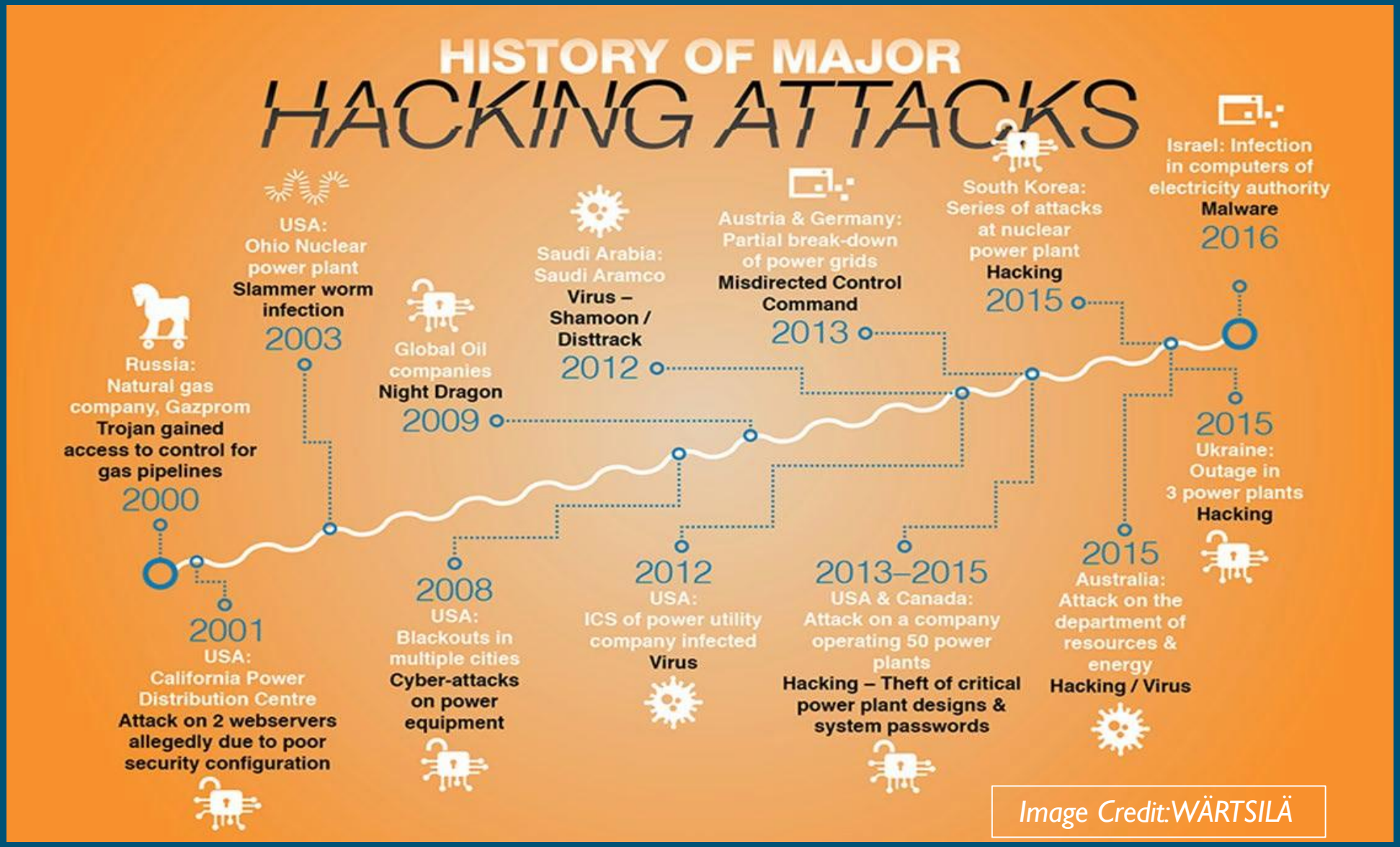
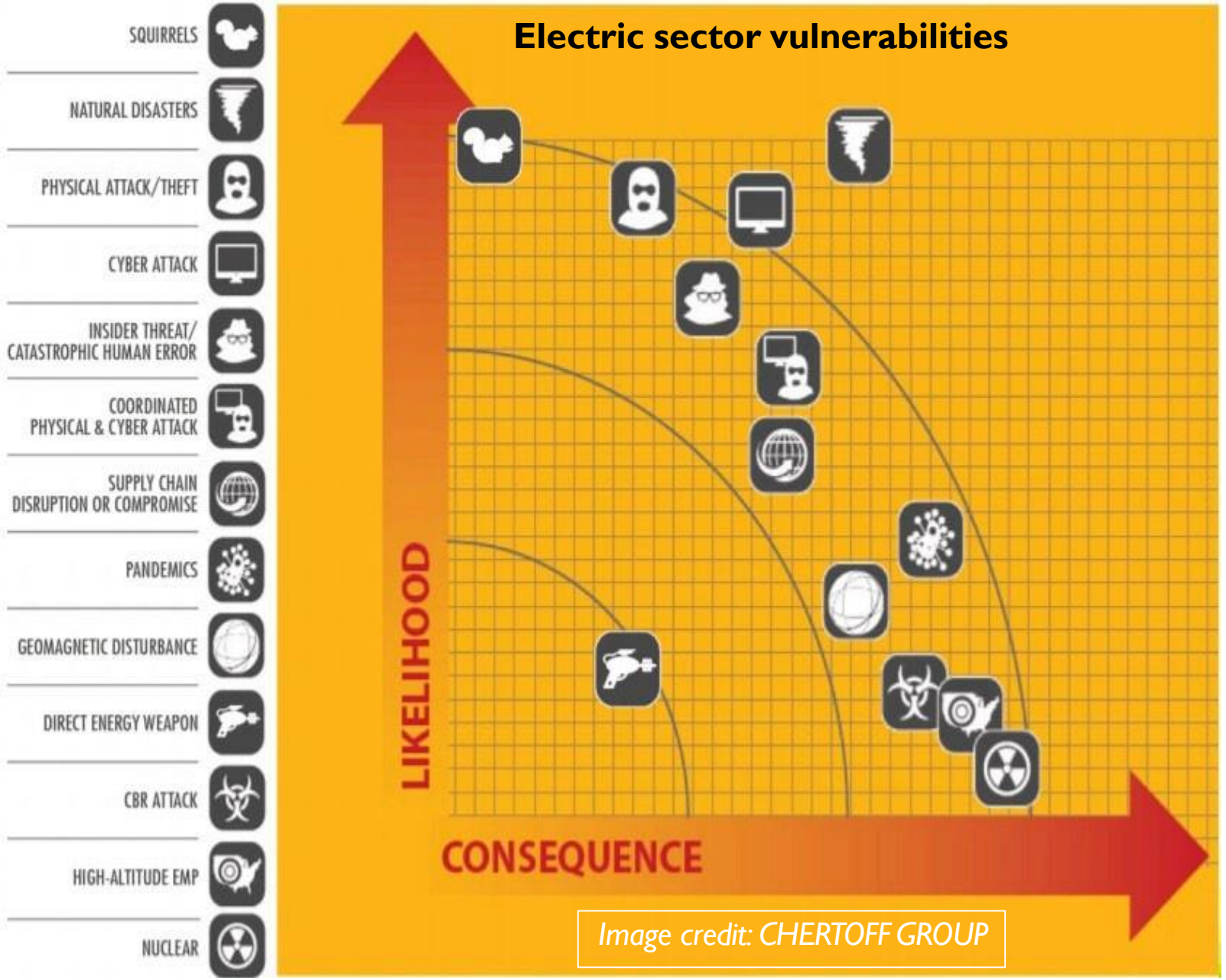


Image Credit:WÄRTSILÄ

"You don't really know better until you do better."

Existing grid planning framework does not effectively deal with high-consequence events, even if those that are likely!



Resilience can be considered an extension of Reliability…

Resilience

Includes Reliability concepts, but also ***low probability, high consequence*** events.

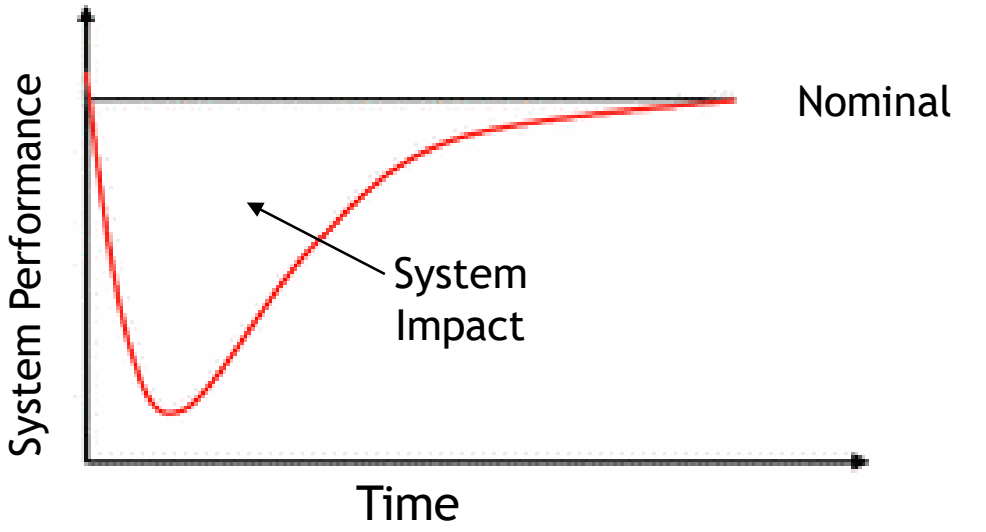
Not widely adopted for grid infrastructure investment. Need new ***methods, metrics and tools***

Reliability

Focuses on system performance with respect to **commonly expected events** (component failure, etc.)

Widely adopted for infrastructure investment decision-making.

Defining Resilience



Ability to **Prepare for, Withstand and Recover from** disruptions caused by major **Accidents, Attacks, or Natural Disasters.**

Pop Quiz

What problem are we trying to solve?

☒ Improve resilience of the whole grid

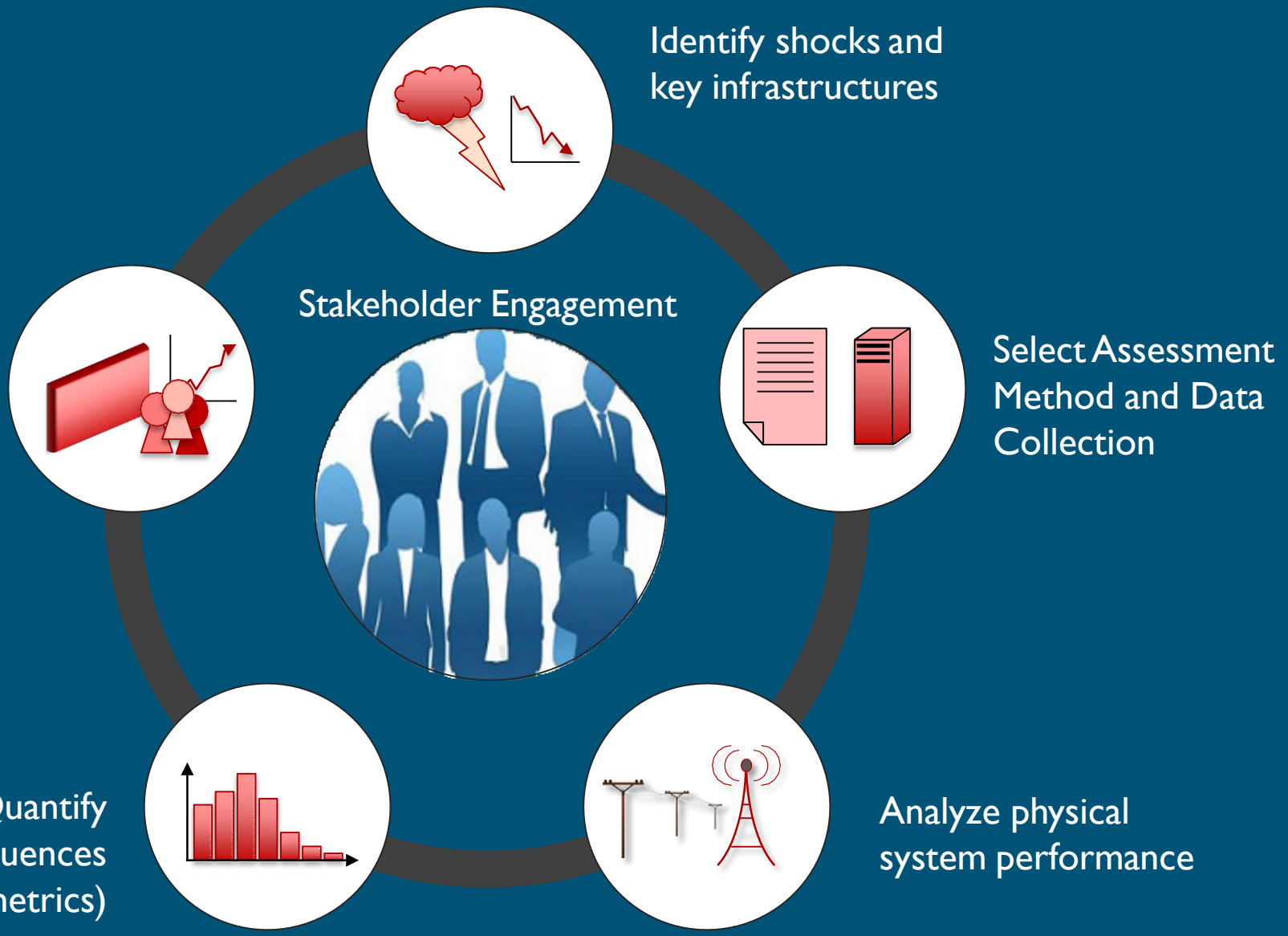
☐ Improve resilience of infrastructure that supports critical services at selected locations

A consequence-based view of Resilience

Measure	Examples of Resilience Metrics
Economics	Gross Municipal Product / Net Economic Losses
	Change in Capital Wealth
	Business Interruption Costs
People and Community	Number of People Without Basic Services
	Lives at Risk
	Societal Burden to Acquire Services

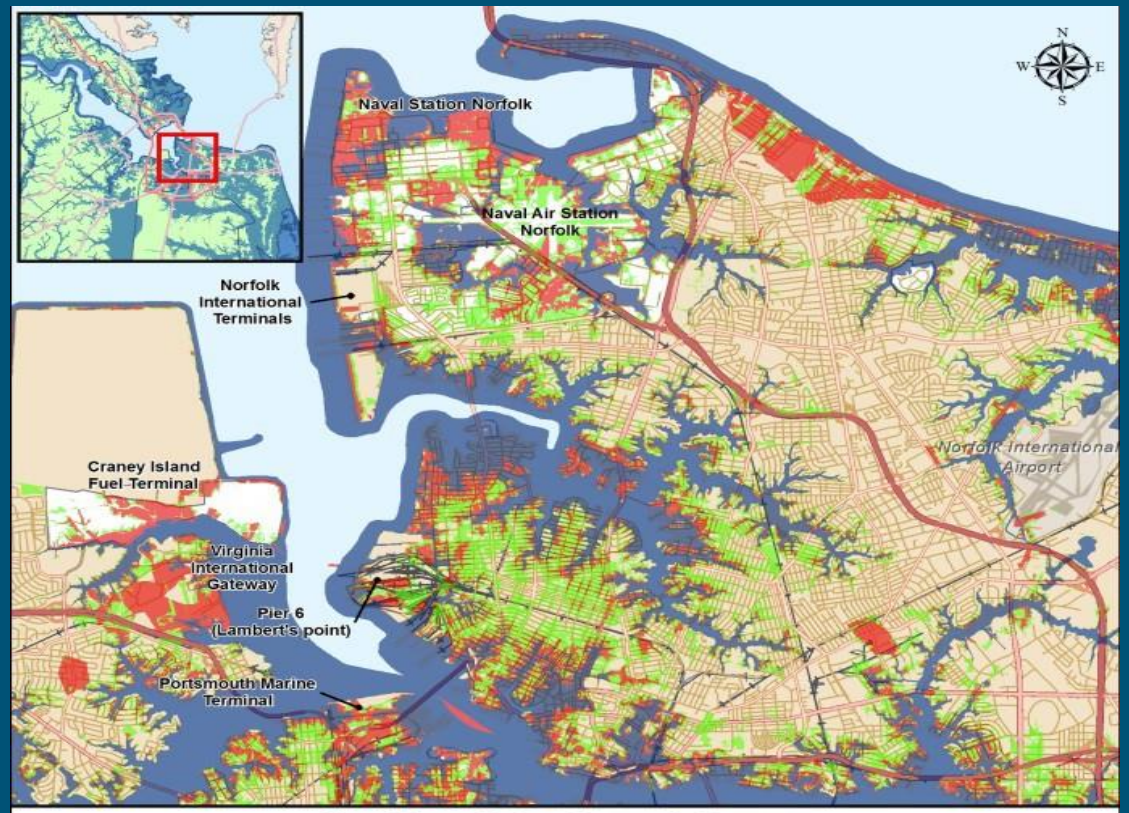
Image Credit: REUTERS / S. Stapleton

A Resilience Planning Framework



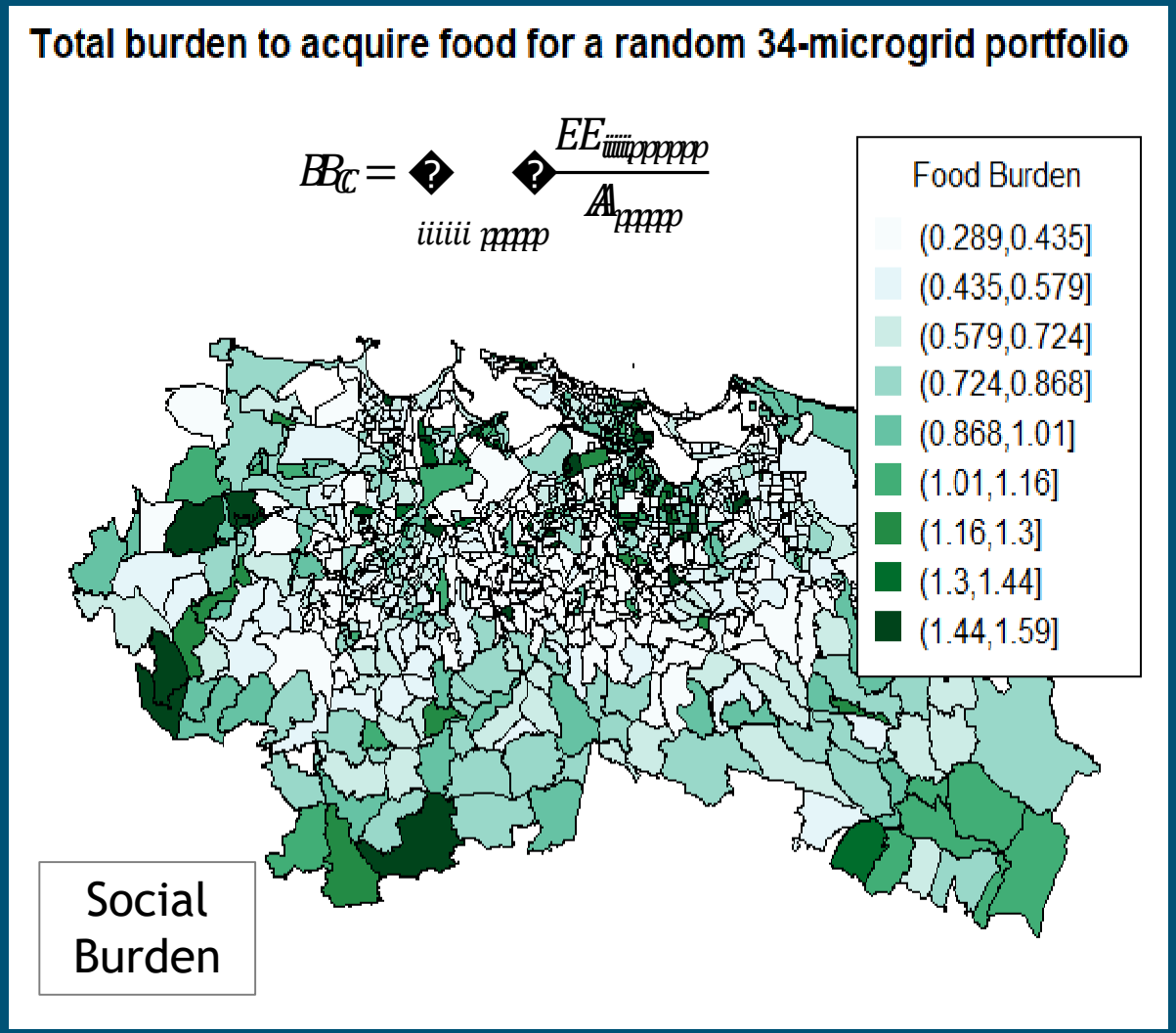
Resilience Analysis using Economic and Community Metrics

Norfolk, VA

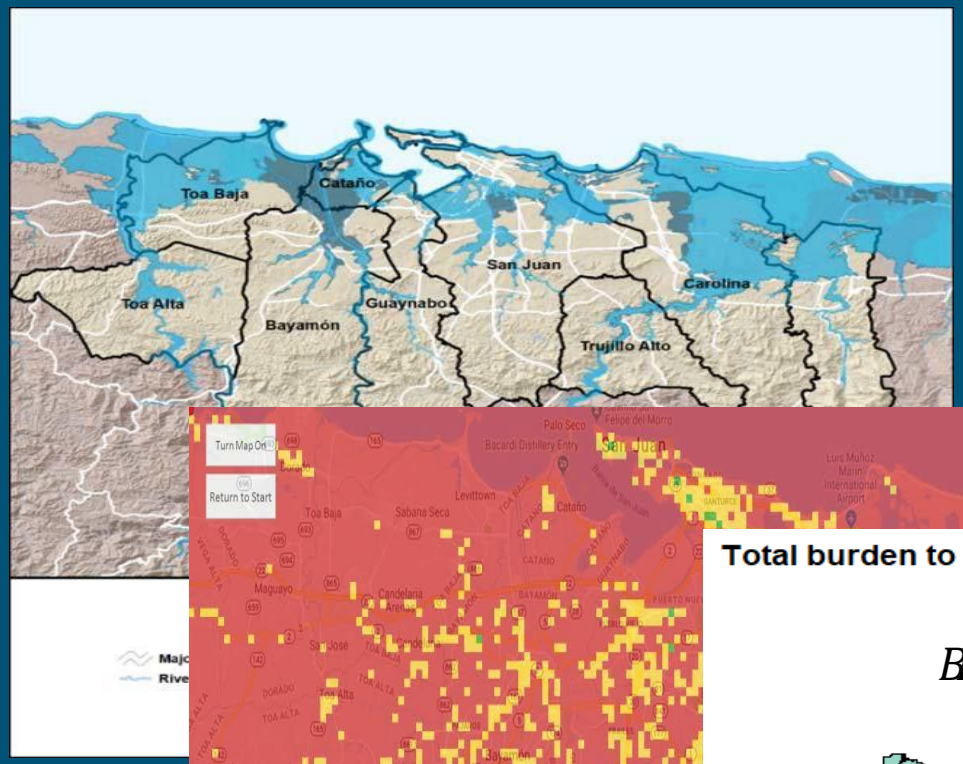


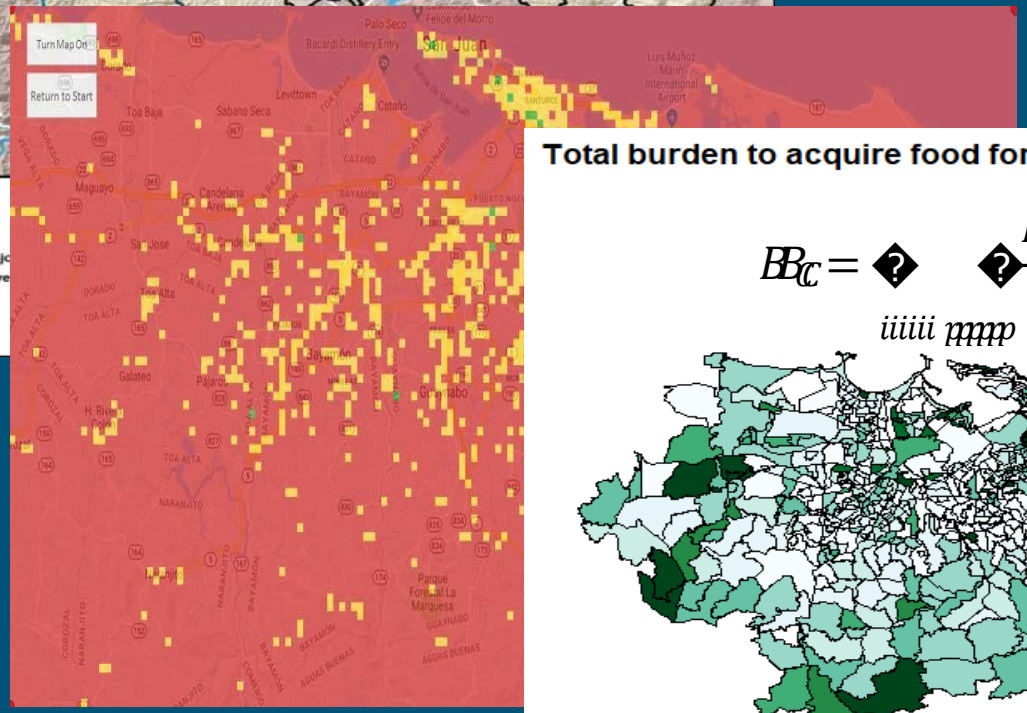
	100yr+0ft	100yr+1.5ft	100yr+3.0ft
Annual Direct Losses	$135 M	$182 M	$231 M
Annual Indirect Losses	$219 M	$296 M	$375 M
Total	$354 M	$478 M	$606 M

San Juan, PR

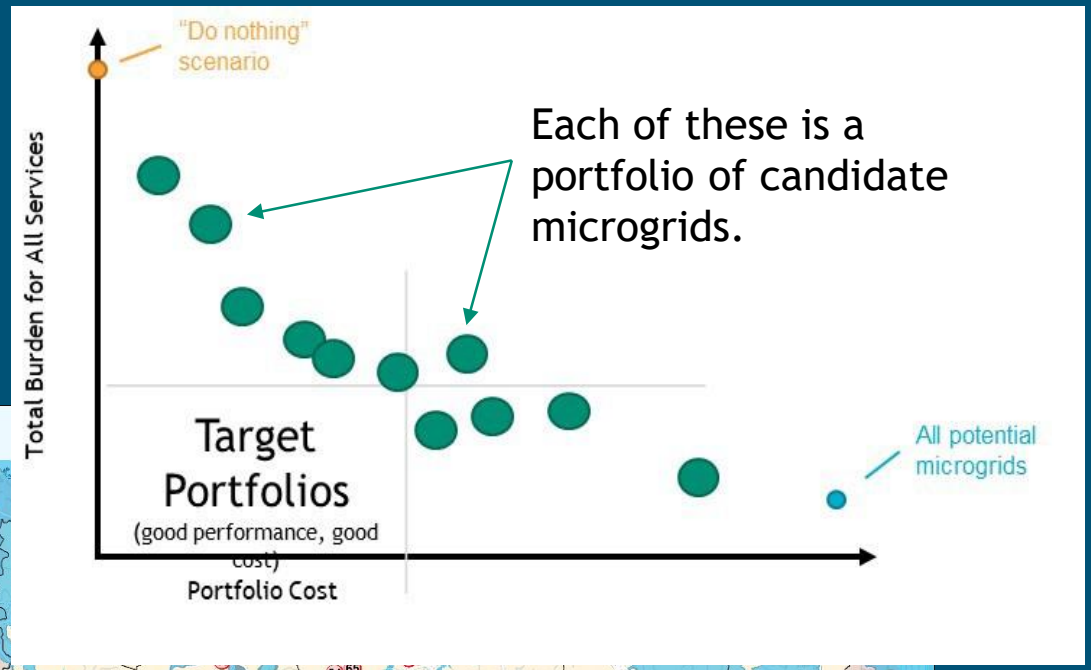


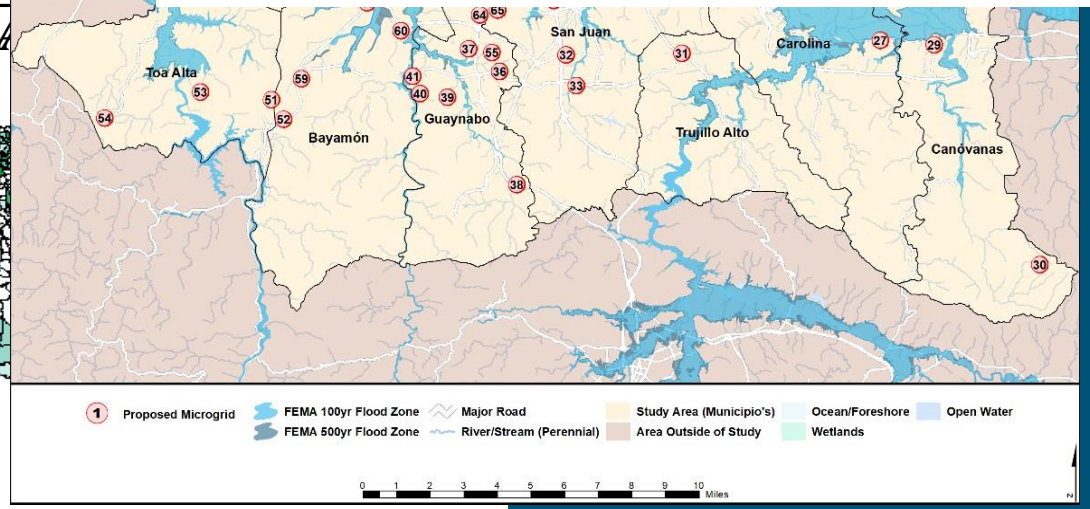
Resilience Planning Process in Action – San Juan, PR

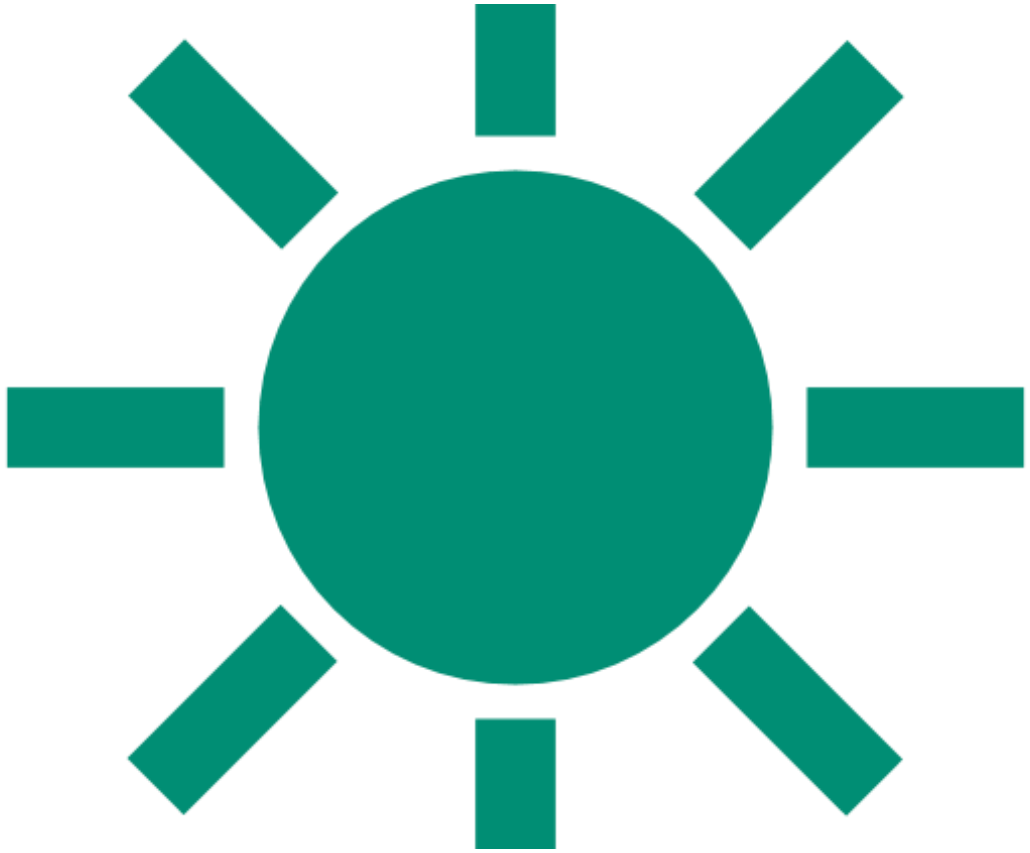




Social Burden



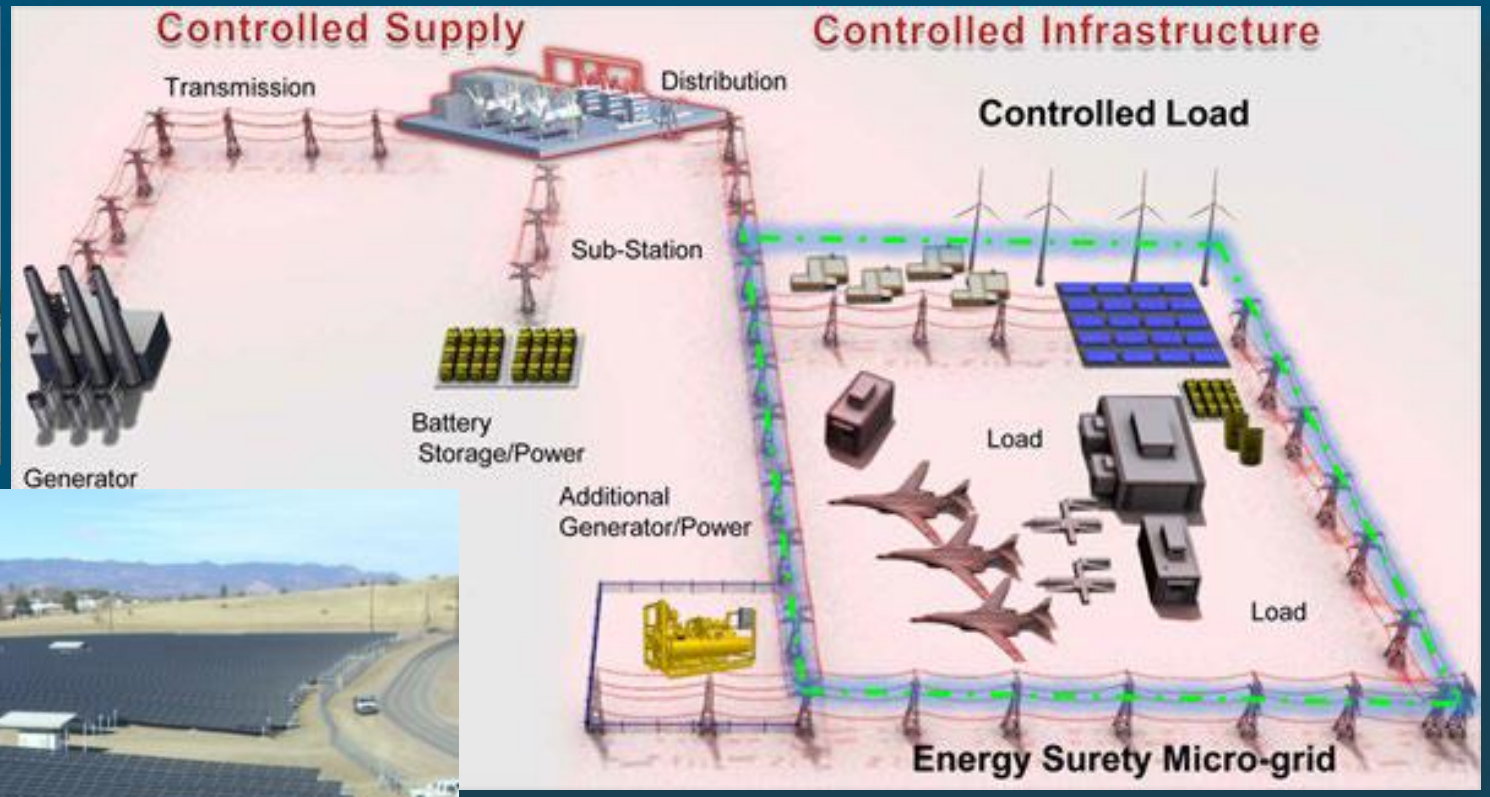




Energy Resilience – A Case for PV *

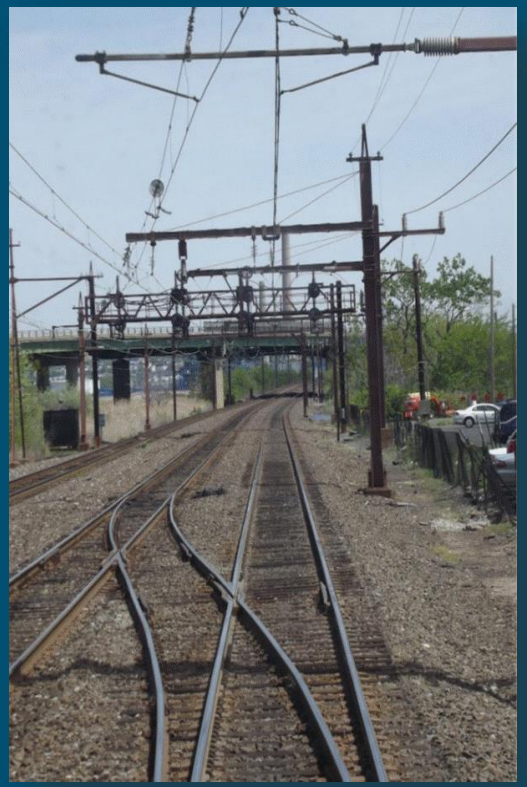
- Rugged, dependable
- Modular, scalable, portable
- Fuel avaialble onsite, everywhere
- **And** generates value all the time!

* As part of a grid-tied microgrid with storage and/or other fuel, depending on the application.



Hybrid microgrid supporting USArmy's Ft Carson in Colorado Springs,CO

Large hybrid microgrid supporting rail and ferry transportation in Newark, NJ (under development)



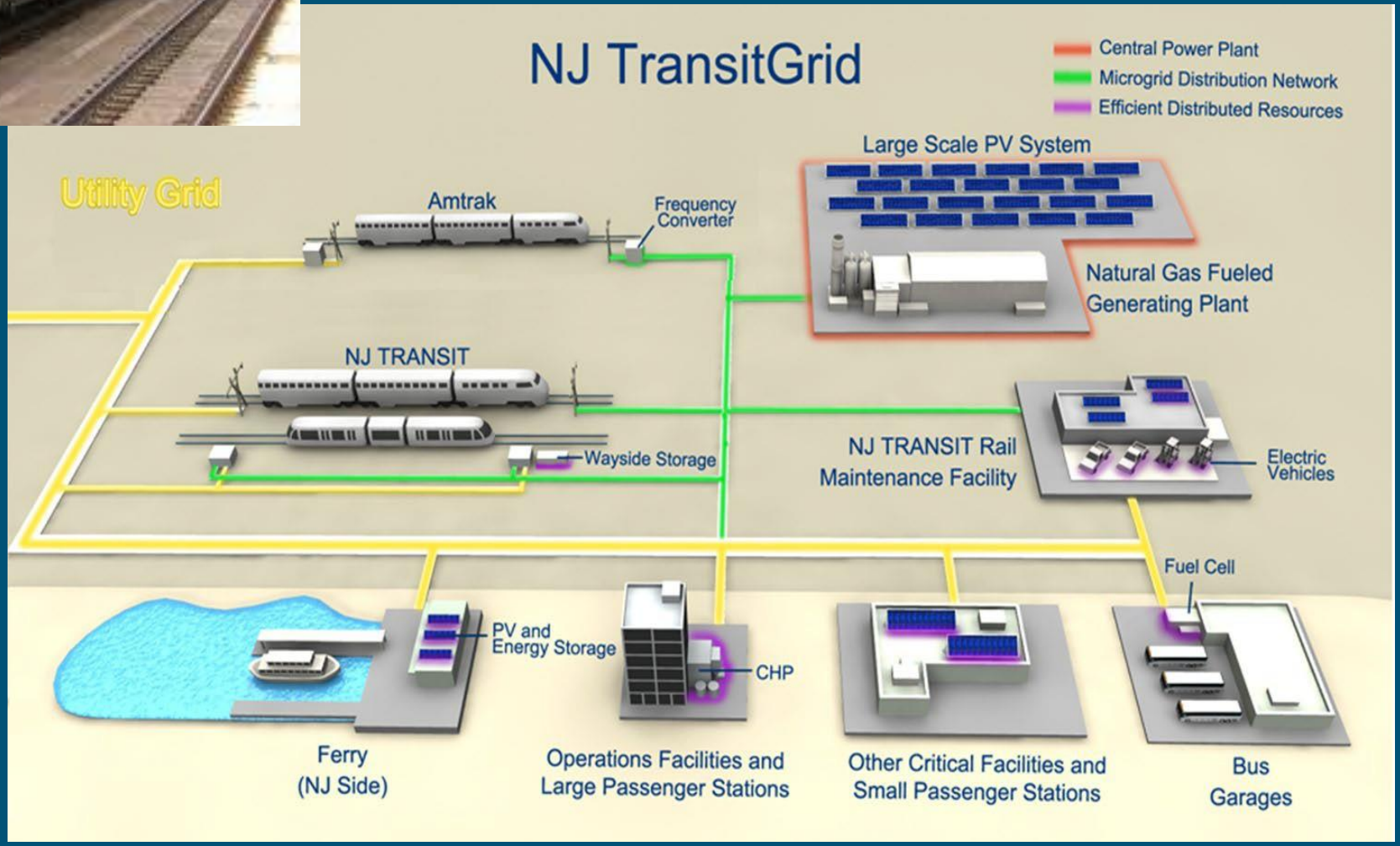


Image Credit: Green Mountain Power

PV + Storage Microgrid supporting community resilience in Rutland, VT

Image Credit: Eos Energy Storage

PV + Storage Microgrid for a water treatment facility in Cardwell, NJ

Necessary Institutional and Technical Considerations

Resilience-based planning methods

New regulatory & business models

Proactive codes and standards

Advanced power electronics: Grid-tied grid-forming inverters

Advanced grid architectures: Dynamic, Networked microgrids

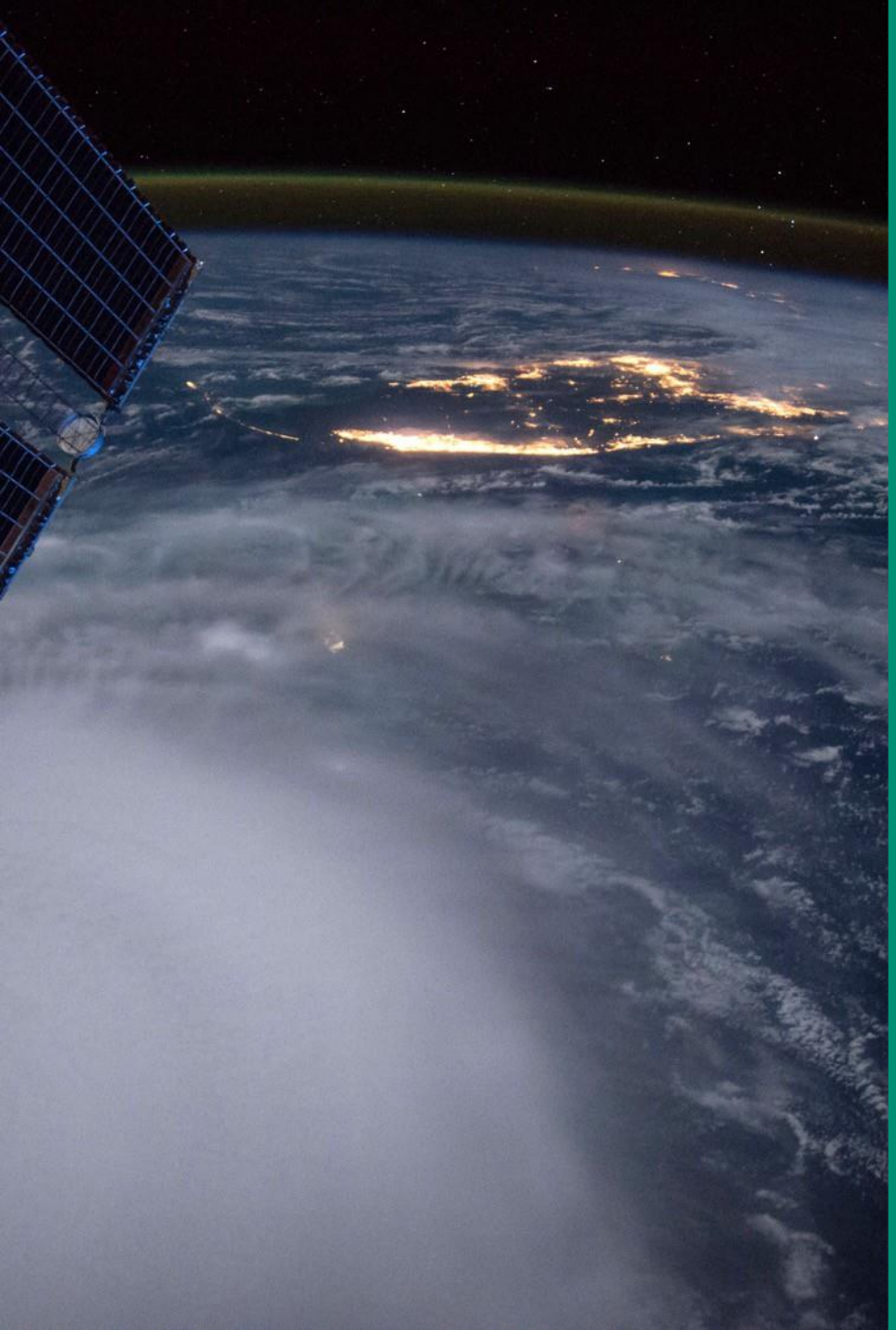
Resilience by Design: Built-in Physical and Cyber Security

What problem will we solve with a large fleet of PV-based resilient microgrids?

- ❒ Improve resilience of the whole grid
- ❒ Improve resilience of infrastructure that supports critical services at selected locations

Pop Quiz, Reframed

Bonus: access to a vastly larger market for solar!



Closing Argument

- ❑ Planning for resilience is an imperative
- ❑ Need practical methods, models, tools
- ❑ Solar can and must play a key role
- ❑ Time to think really big:

Solar can indeed enable a sunny and resilient energy future!