

Curating Energy Resilience Toolkits



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Purpose

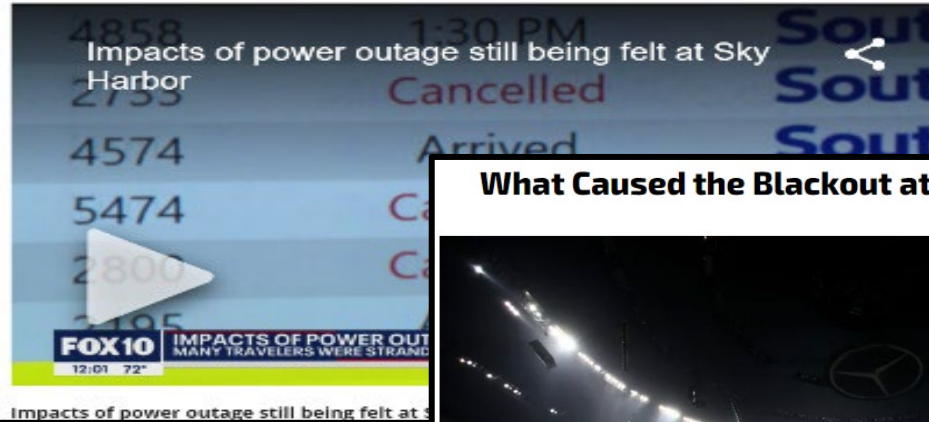
This presentation offers some new ideas about resilience and how to curate a resilience toolkit

We will also answer the question:

“What is resilience and how do I get some?”

A case for a resilience toolkit

Power outage caused many flight cancellations, delays



Cleaning crew blamed for RDU power outage

Tags: power outage, RDU Airport, travel, air travel

Posted November 12, 2021 5:05 a.m. EST

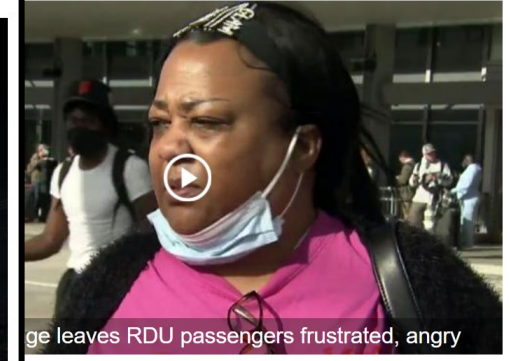
Updated November 12, 2021 5:23 p.m. EST

What Caused the Blackout at Super Bowl 47?



Photo by Dilip Vishwanat/Getty Images

Power restored at Phoenix Sky Harbor Airport, delays continue Monday evening



Nov 8, 2021

Reply Share

Read 1 reply

Phoenix Sky Harbor International Airport @PHX... · Nov 8, 2021

Replying to @PHXSkyHarbor

Due to the power outage, some restrooms are out of order on level 2 of Terminal 4. Restrooms are open on level 3 and on the west end of levels 1 and 2.



Phoenix Sky Harbor International Airport @PHXSkyHarbor

UPDATE: Power has been restored to Terminal 4 and all systems are quickly returning to regular operation. Passengers should continue to check flight status with their airline before coming to Sky Harbor. Delays are likely into the evening.

2:13 PM · Nov 8, 2021

BOLTs: Basic One Line Takeaways

Four BOLTs:

1. International events demonstrate value of resilience
2. Huge amount of resilience tools & resources available
3. Case studies demonstrate value of resilience tools
4. Resilience is scalable and starts at home

“Do not judge me by my success, judge me by how many times I fell down and got back up again.”

- Nelson Mandela

Presentation Overview

1. Resilience defined
2. Building a resilience toolkit
3. Resilience case studies
4. Grass roots tips

INTRO

Definition
Toolkit
Case Studies
Tips

Presentation Flight Plan



- Key questions
 - What does resilience mean?
 - How do we measure it?
 - What is really critical?
 - What scenarios do we plan for?
 - Where do we invest our resources?
- The Tyndall Standard:
 - Old: Recover in weeks/years
 - New: Rebound in hours/days
- Trends

Hurricane Michael showed how woefully unprepared the military is for extreme weather

The military says climate change is a “threat multiplier.” It’s still struggling to prepare for those threats.

By Umair Irfan | Updated Oct 16, 2018, 9:44am EDT

f t SHARE



Static display aircraft blown over by Hurricane Michael at Tyndall Air Force Base. | Brandon Clement/Live Storms Media

“If I had only one hour to save the world, I would spend fifty-five minutes defining the problem, and only five minutes finding the solution.”

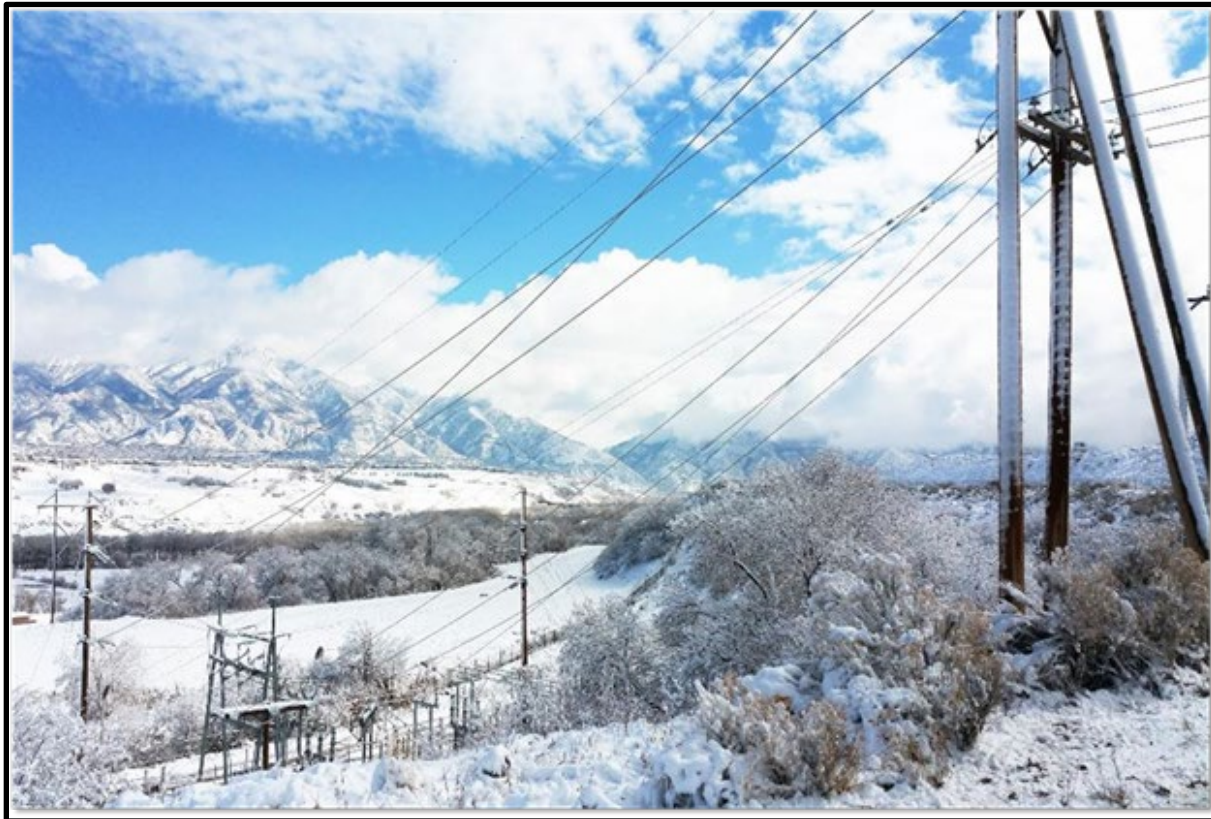
Albert Einstein

The definition for the term “Energy Resilience,” as seen in the Fiscal Year 2018 National Defense Authorization Act

What is...?

- A. The ability to bounce back after a disruption.
- B. Keeping the lights on.
- C. The ability to avoid, prepare for, minimize, adapt to, and recover from anticipated and unanticipated energy disruptions in order to ensure energy availability and reliability sufficient to provide for mission assurance and readiness, including mission essential operations related to readiness, and to execute or rapidly reestablish mission essential requirements.
- D. Never having to thaw out your frozen crow.

“The thing about resilience is that there is always another test looming on the horizon”



- Human
 - Accident
 - Terrorism
 - Cyber attacks
- Natural
 - Storm
 - Fire
 - Flooding
 - Freezes
 - Failure due to age and long term weather exposure

AP | September 21, 2016, 6:30 PM

Puerto Rico hit with islandwide blackout after fire erupts

12 Comments / f Share / Tweet / Stumble / @ Email

Last Updated Sep 21, 2016 7:50 PM EDT

SAN JUAN, PUERTO RICO | A big fire erupted at an electricity plant that powers most of Puerto Rico on Wednesday, causing a blackout that swept across the U.S. territory of 3.5 million people.

The Electric Power Authority said two transmission lines of 230,000 volts each failed. Executive Director Javier Quintana told reporters that he expected most power to be restored by Thursday morning, adding that airports, hospitals, police stations and water plants would get priority.

"The entire island is without power," said Angel Crespo, director of Puerto Rico's fire department.

Large transformers damaged by unknown attackers in CA
Source: CNN



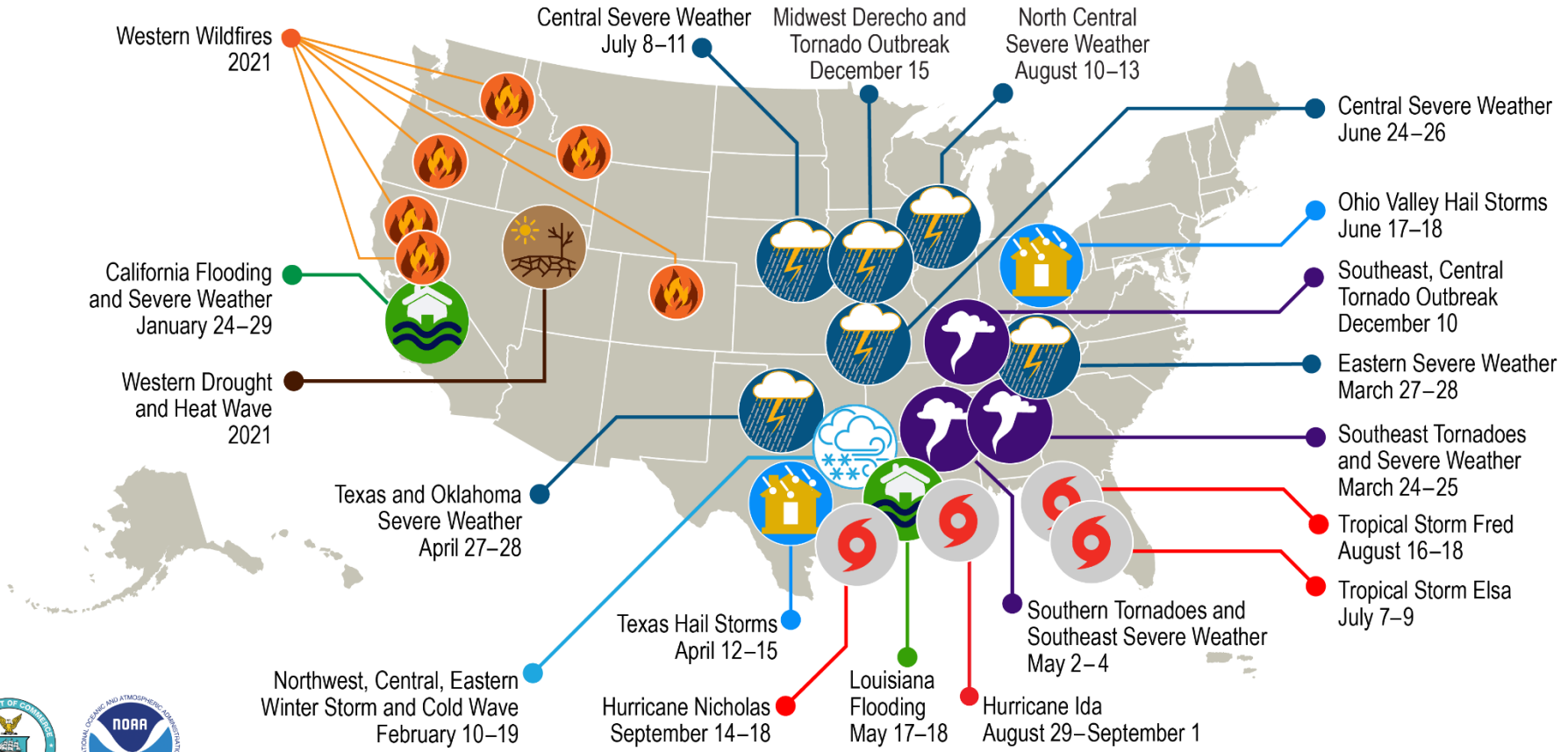
Europe faces gas shortage as Russia cuts Ukraine supply after talks fail

Ukraine fails to broker an 11th-hour deal with Russia, causing Moscow to effectively halts all shipments from Monday morning

Resilience = Response to Threat

U.S. 2021 Billion-Dollar Weather and Climate Disasters

Drought/Heat Wave
 Flooding
 Hail
 Hurricane
 Tornado Outbreak
 Severe Weather
 Wildfire
 Winter Storm/Cold Wave



This map denotes the approximate location for each of the **20 separate billion-dollar weather and climate disasters that impacted the United States in 2021**

Source: NOAA National Centers for Environmental Information (NCEI) U.S. Billion-Dollar Weather and Climate Disasters (2022).

<https://www.ncdc.noaa.gov/billions/>



Five Air Force Rs of Resilience

1. Robustness
2. Redundancy
3. Resourcefulness
4. Response
5. Recovery



Final thoughts on Terminology

- The buzz behind the buzzword
- Everybody wants some...
- Another Definition: “Keeping the crow on ice” (version 5.0)
- Personal resilience

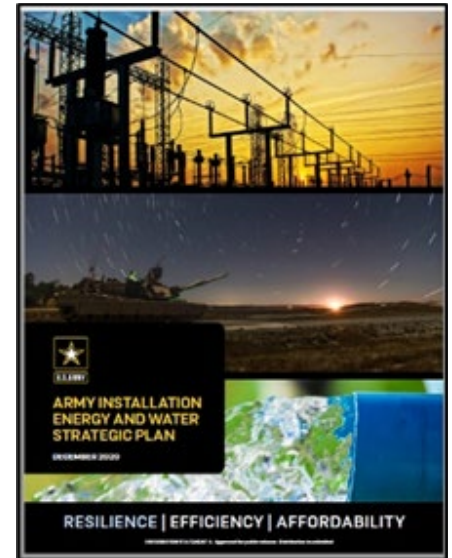


- Guidance
- Trends
- Resources
 - Ingredients
 - Building blocks
 - Info resources



Munitions Storage Area Radio Replacement

- Quadrennial Energy Review
 - TS&D infrastructure resilience, reliability and security
 - Modernize the electric grid
- Presidential Policy Directive 21 (PPD-21),
“Critical Infrastructure Security and Resilience.”
- NOAA Climate Resilience Toolkit
- FEMP online “Solution Center”
- Army Installation Energy & Water Strat Plan

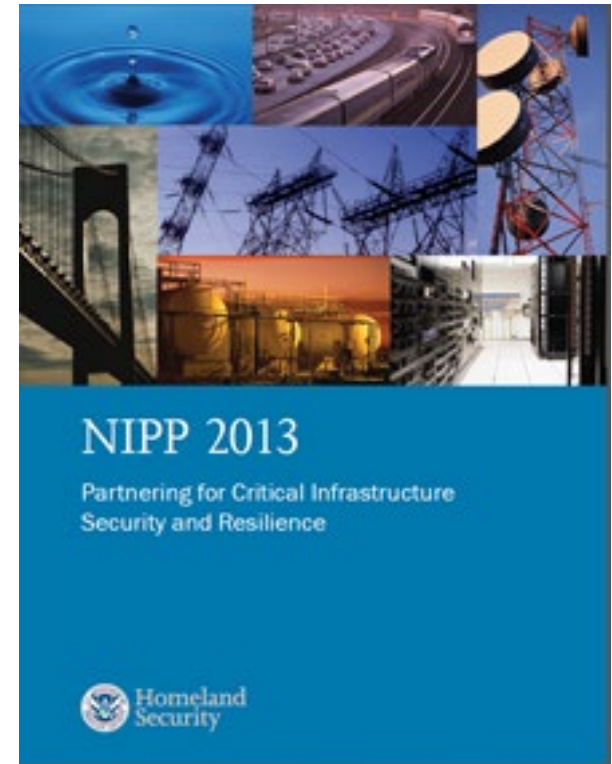


“The spirit of resiliency defeats all trials and tribulations.”

Edmond Mbiaka

Resilience is about Mitigating Consequences

- Improve situational awareness
- Plan for quick restoration
- Prioritize essential services
- Upgrade to resilient infrastructure
- Use high-tech emergency comms
- Partner locally and regionally



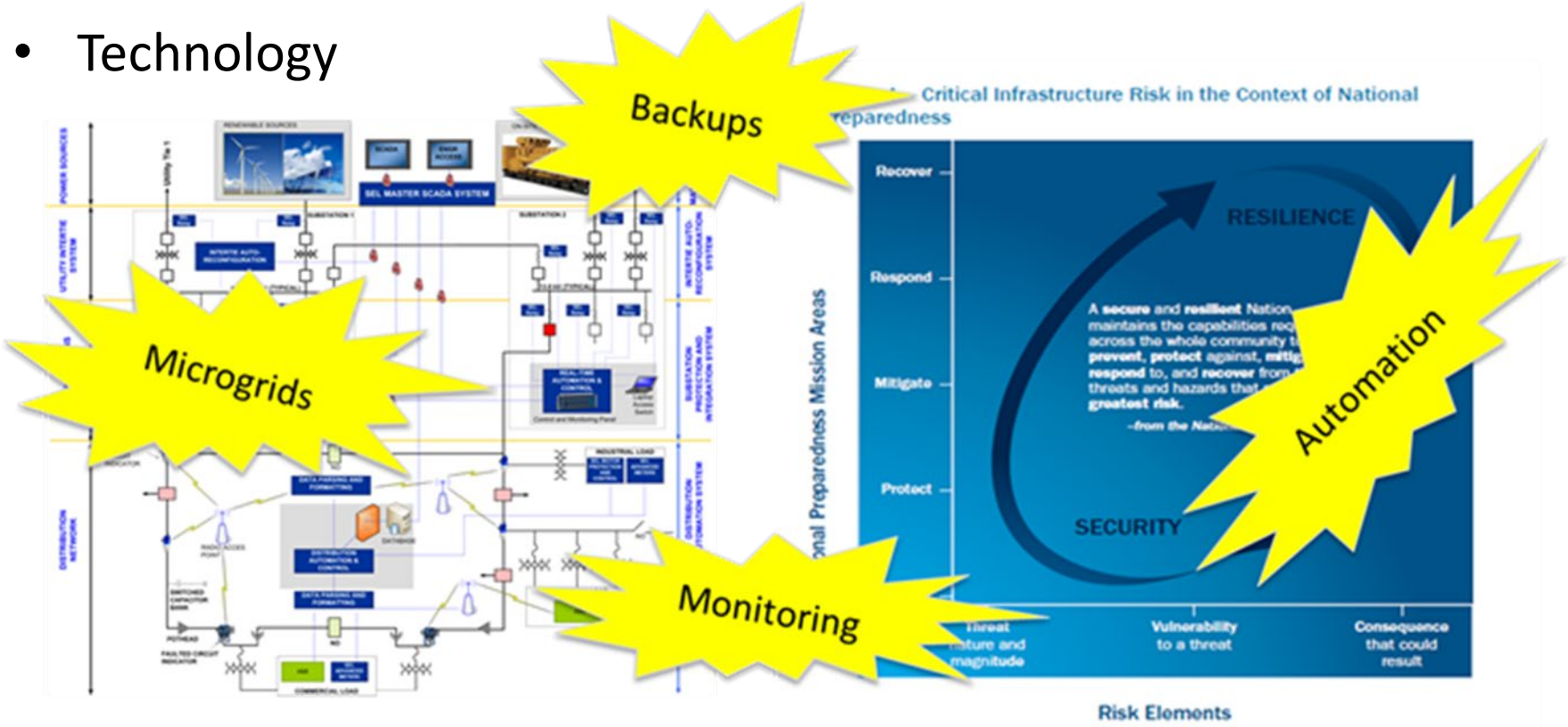
Source: National Infrastructure Protection Plan



Source: National Infrastructure Protection Plan

Guidance: Countermeasures

- Protection
- Processes
- Redundancy
- Technology



- 500 fixed installations: 30% DoD energy use
- Must prepare for and recover from energy disruptions
- Ensure available, reliable and quality power to accomplish missions
- Properly size energy generation systems
- Pursue non-material & behavior-based solutions

“Energy availability and resilience define and enable the capabilities of weapons platforms, facilities, and equipment while remaining a substantial expense that competes with other investments in both manpower and equipment. These issues compel DoD to pursue cost-effective measures that increase energy resilience and reduce our cost of operations.”

2016 DoD Annual Energy Management & Resilience Report

The Challenge for DoD

- **Difference between Effective Ops and Efficient Ops**
- **Military operations are inherently not efficient**
- **Must balance business case vs. reality of performance**
- **Cyber threats affect what can be done**



Topics from recent conferences and workshops

- **Model for real-time ops of water systems w/limited power**
- **Risk-based assessment of bridges to natural/seismic hazards**
- **Retrospective analysis of hydraulic bridge collapse**
- **Black Sky Hazards Resilience Planning**
- **Water Supply Damage, Recovery and Lifeline Interaction in an Earthquake Sequence**
- **Mapping Slope-Failure Susceptibility for Infra Mgt**
- **The Core Competencies of Resilience**

Ten Ingredients for Infrastructure Resilience

System Configurations:

1. **Planning and Design** – single vs redundant system, microgrids
2. **Technology** – manual vs cyber-secured automations
3. **Construction** – safe, weather-hardened, wildlife-protected

Operations:

4. **Preventative Maintenance** – early response to problems
5. **Operations Support** – SMEs, tools, and management
6. **Dedicated Work Force** – Trained workforce ready to respond

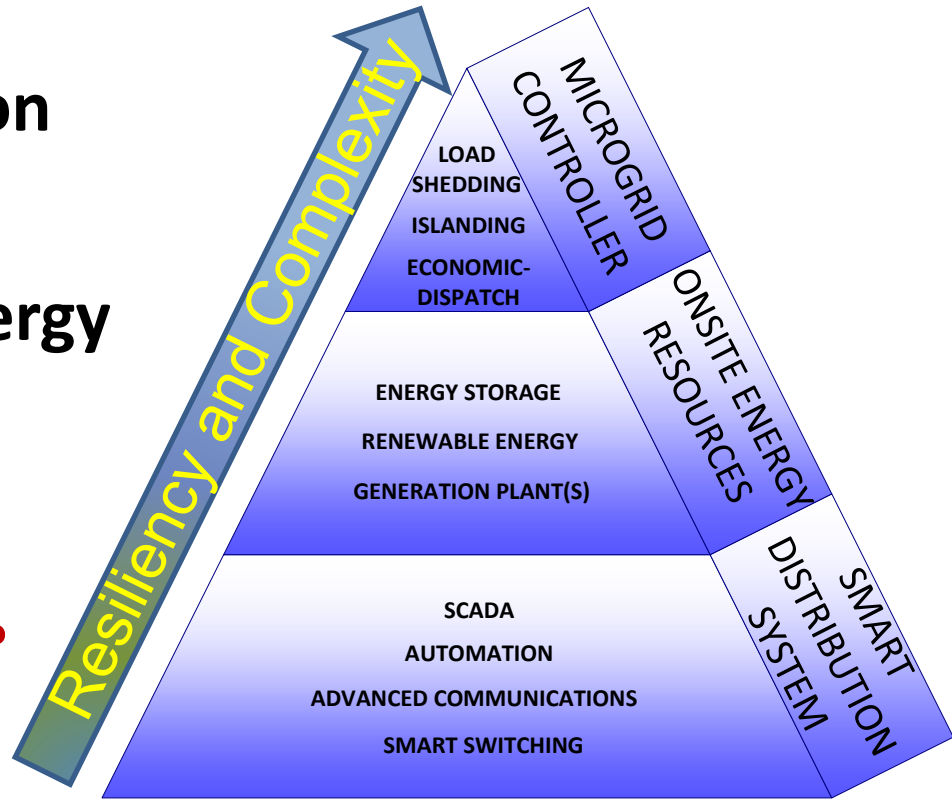
Technical Support:

7. **Standardization** – streamlined response to problems
8. **Training** – develop and maintain trained workforce
9. **Record Drawings** – Accurate maps during crisis response
10. **Reliability Analysis** – tailored upgrades to address real issues

Building Blocks of Microgrid

1. Smart Distribution System
2. Onsite Energy Resources
3. Microgrid

***What is required?**

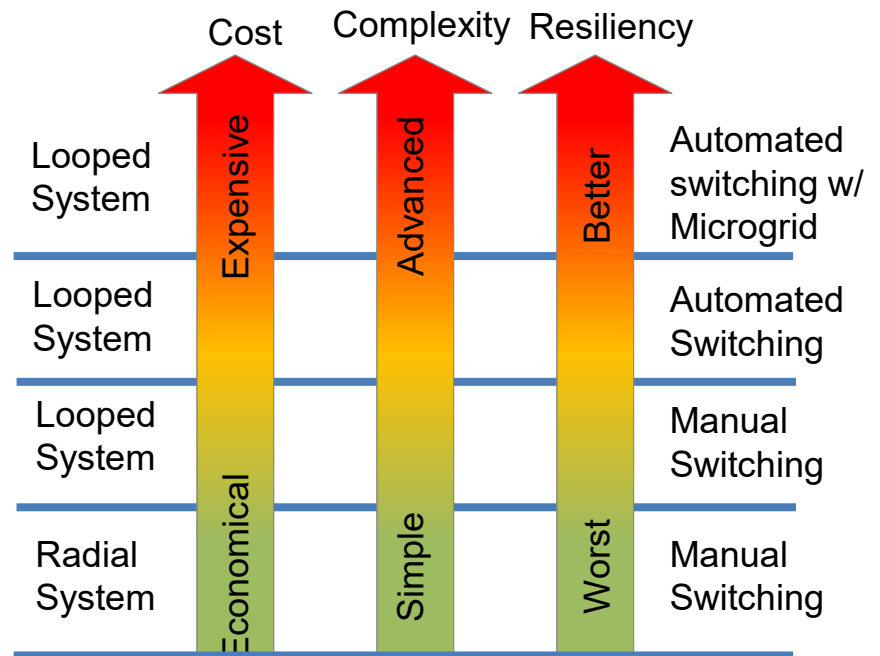


Performance Attributes

Resiliency
Security
Safety
Power Quality
Capacity
Visibility
Reliability
Redundancy
Operability

Scaling Resiliency

- Loops and redundancies with manual switching some what improves resiliency for local outages
- Loops and redundancies with automated switching significantly improves resiliency for local outages
- Loops and redundancies with local energy resources and microgrid capabilities ensure highest level of resiliency – but at what cost?



- **DOE Federal Energy Management Program (FEMP)**
- **DOE Office of Energy Efficiency and Renewable Energy**
- **Resilient-energy.org (USAID-NREL Partnership)**
- **State energy resilience programs (sometimes under DEQ*)**
- **Ready.gov Community Preparedness Toolkit**
- **Communities of Practice (Enviro, Asset Management, Energy)**

U.S. DEPARTMENT OF
ENERGY

Office of
**ENERGY EFFICIENCY &
RENEWABLE ENERGY**



Personal resilience can be contagious

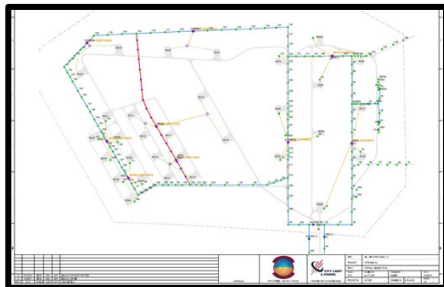
Many examples of how resilience tools work. We'll highlight a few:

- Automation
- Infrastructure redundancy
- Emergency generation and focused grids
- Reducing outage frequency, impact, and duration



Making an AFB Resilient

- Two Hill AFB projects in September 2017
 - Munitions Storage Area Automation
 - Motorized & automated switchgear
 - Real Time Automation Control (RTAC)
 - Secure system radio comms
 - UTTR Munitions Storage Area
 - Redundant transformer system
 - Same control features as HAFB MSA



Case #1: Munitions Storage Area Power Distribution

- Introduce loop of five (5) motorized switches
- VFI technology
- Old: Fault reverberated back to substation
- New: Localized impact, quickly resolved
- VFI switches isolate problems
- RTAC reflows power
- RTAC is the “brain”



RTAC



Motorized VFI Switch

- On 8/7/21 a government-owned power cable near the airfield failed, causing a fault in Hill AFB electrical distribution system near Munitions Storage Area (MSA).
- CLP automation system immediately detected & isolated fault...reflowed power

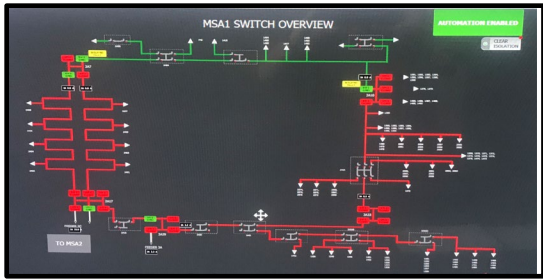
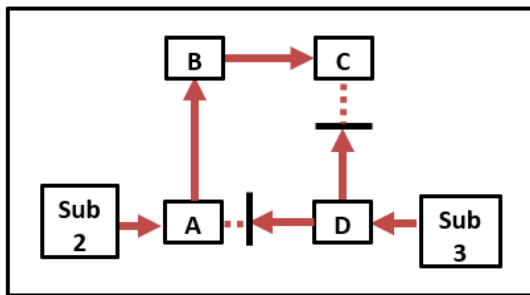
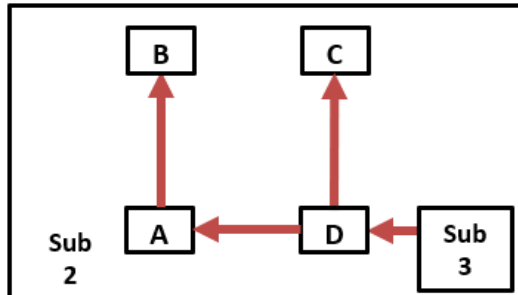


Photo of system display during outage...
Yellow boxes highlight the fault.
Green lines show power is not flowing.

- System prevented outage to hundreds of buildings.
- CLP crew on site before customers knew of outage.**
- Troubleshooters knew fault location before arriving.
- Normally Substation #2 feeds power points A→B→C and Substation #3 feeds power at point D & toward C.
- After restoration, Sub #3 fed entire MSA: D→A→B.

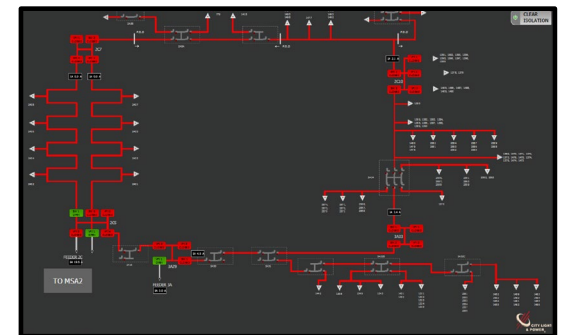


Before: Normal flow A → B → C



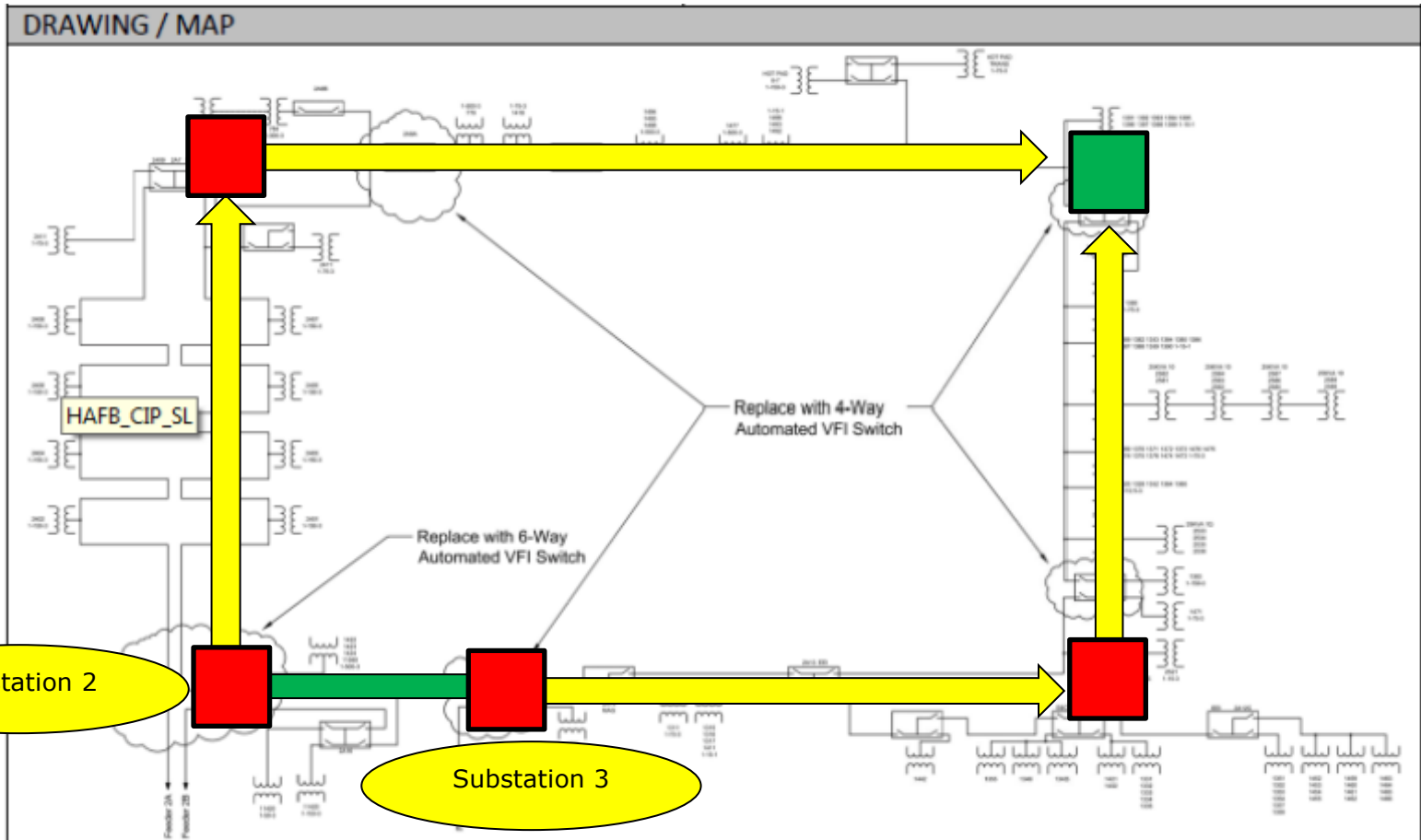
After power restoration: D → A → B

- Automation reduced outage scope and duration.
- Prior to system upgrades, fault would have shut down feeder 2C & much of MSA for over an hour.



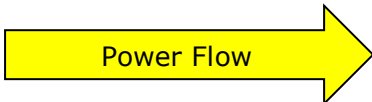
Normal system display after outage...
Red lines show power flowing

MSA Normal Configuration



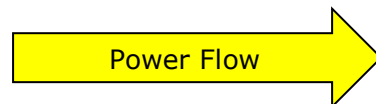
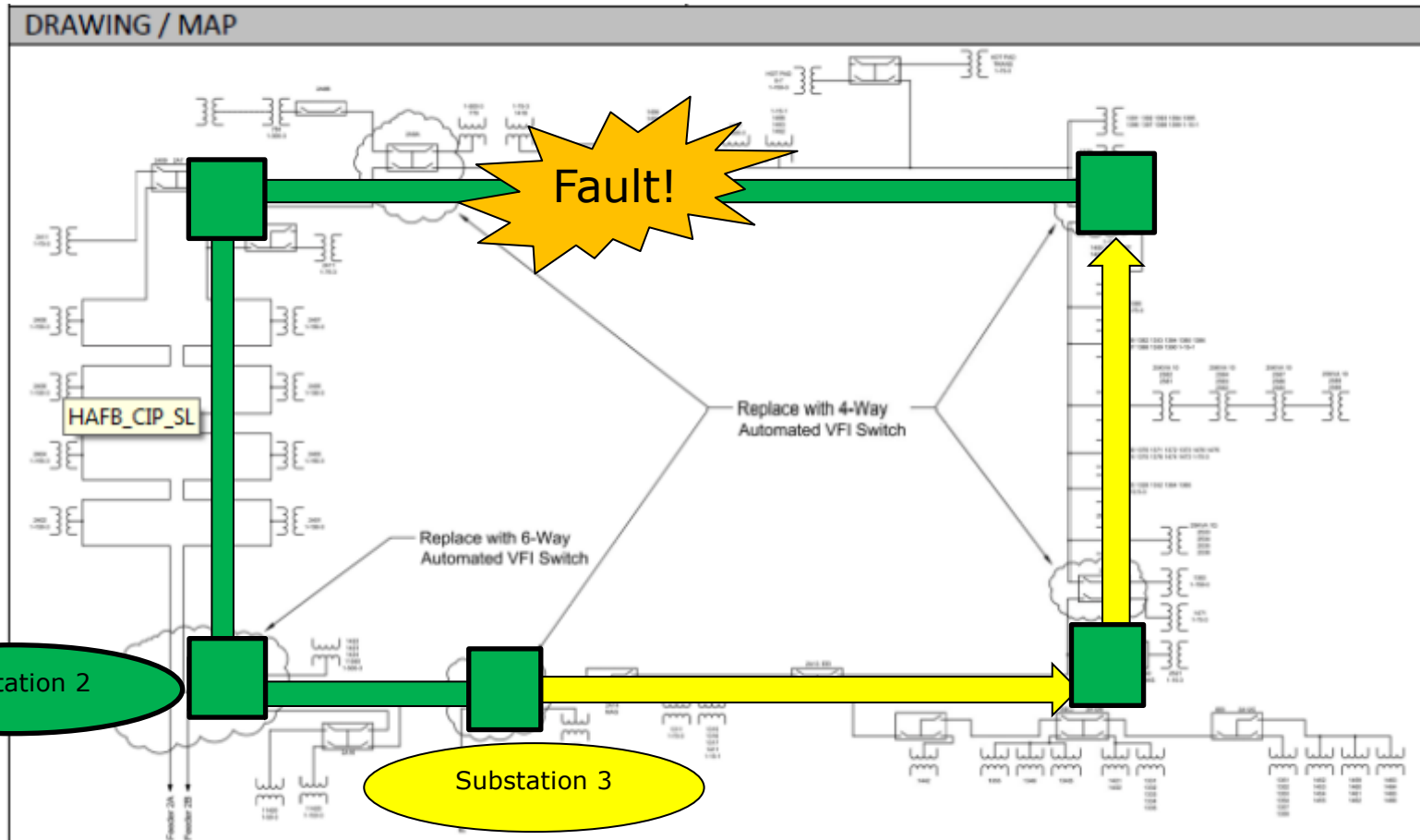
Substation 2


Substation 3



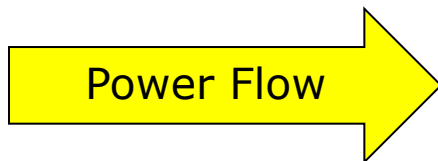
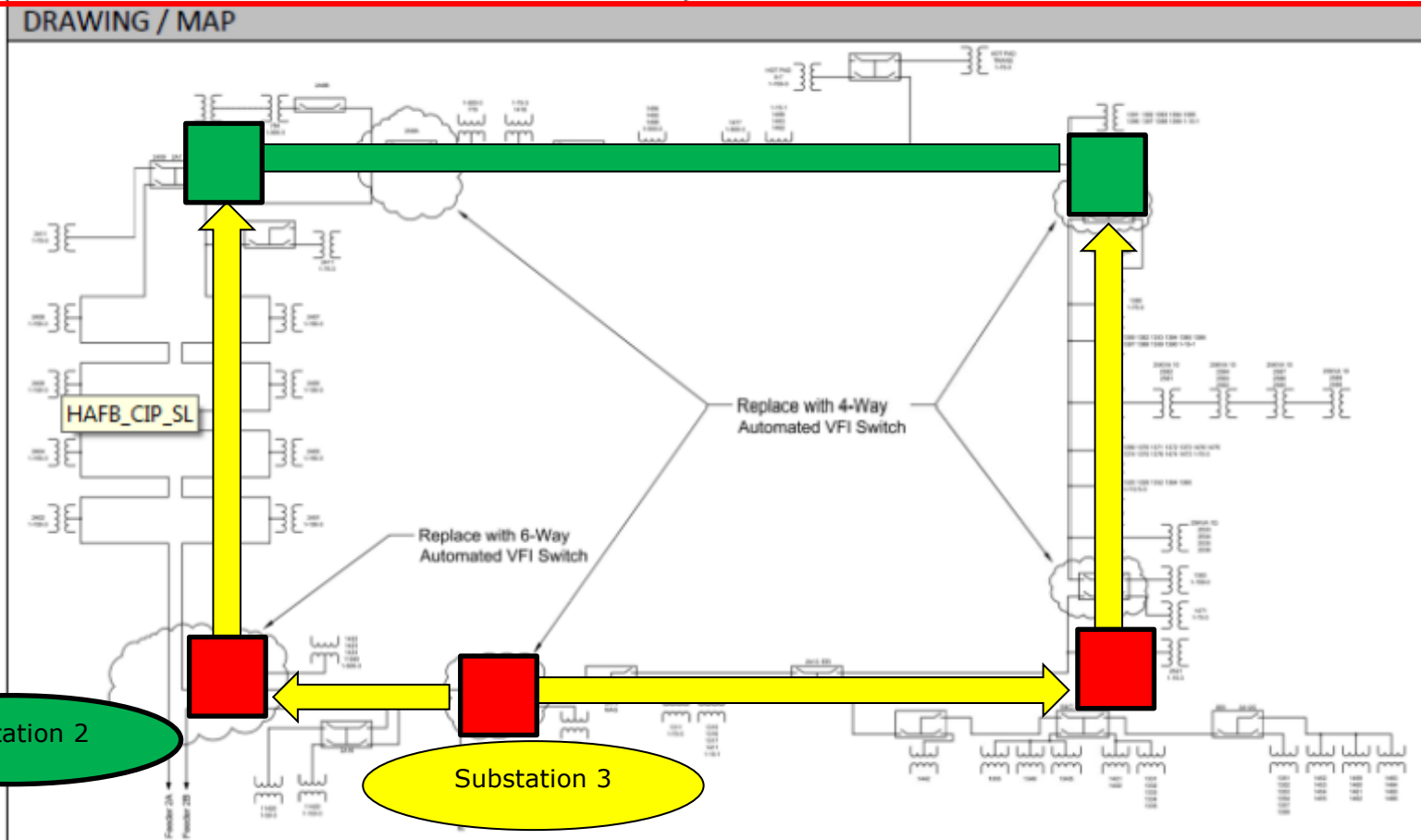
 = Motorized Switch


MSA Reaction to a Fault



 = Motorized Switch

Reconfigured Power Flow Thirty Seconds Later...

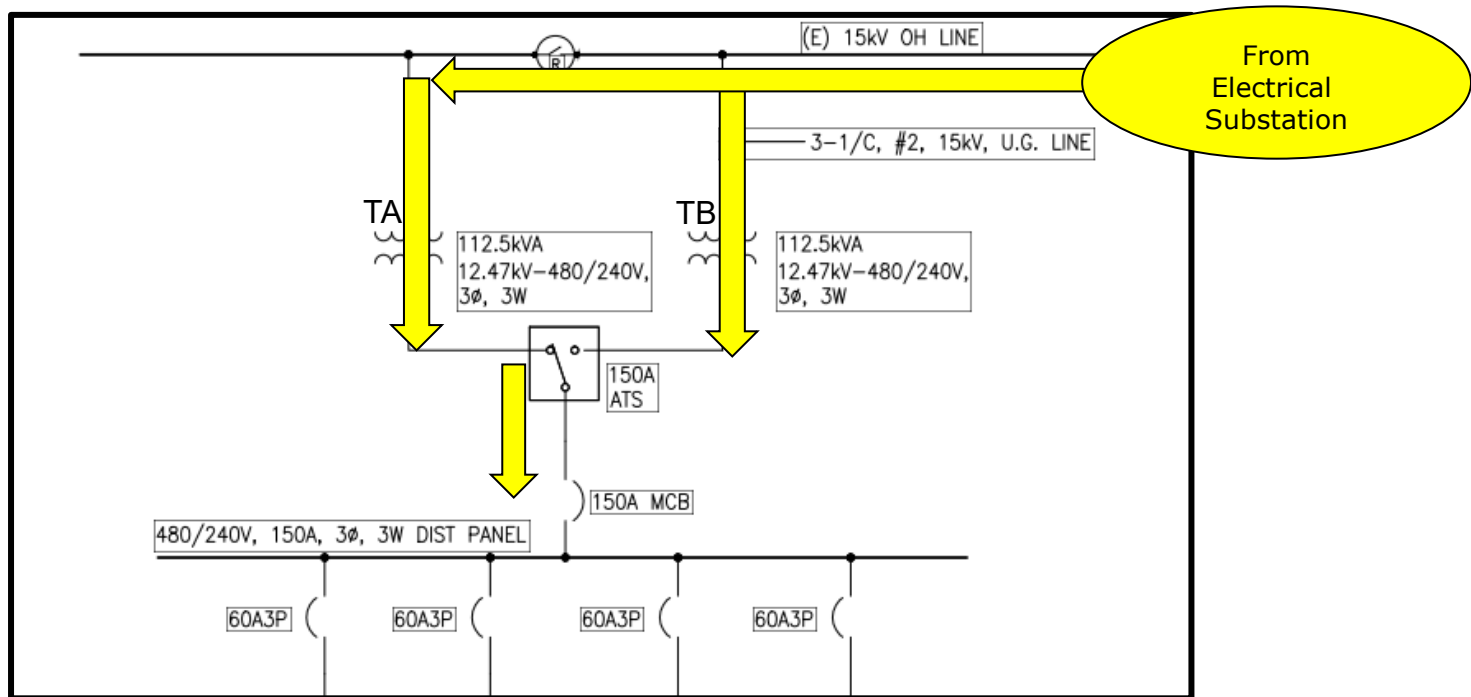


 = Motorized Switch
(red=closed, Green=Open)

Case #2: UTTR MSA Power Platforms



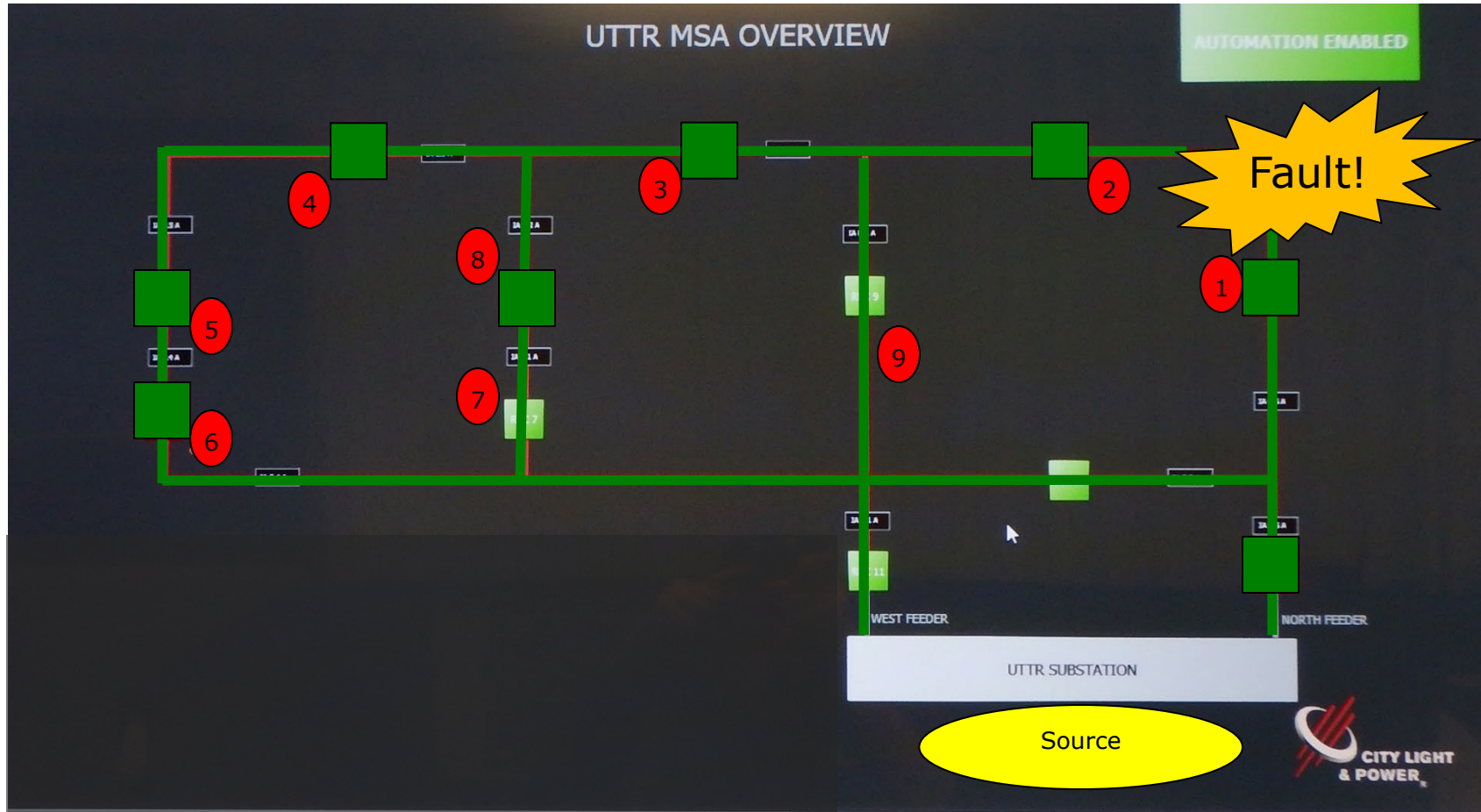
- Old model: Transformer bank at each building
- Now: Paired transformers (TA & TB) at platforms
 - Four (4) buildings fed from a typical platform
 - TB picks up load if TA goes down



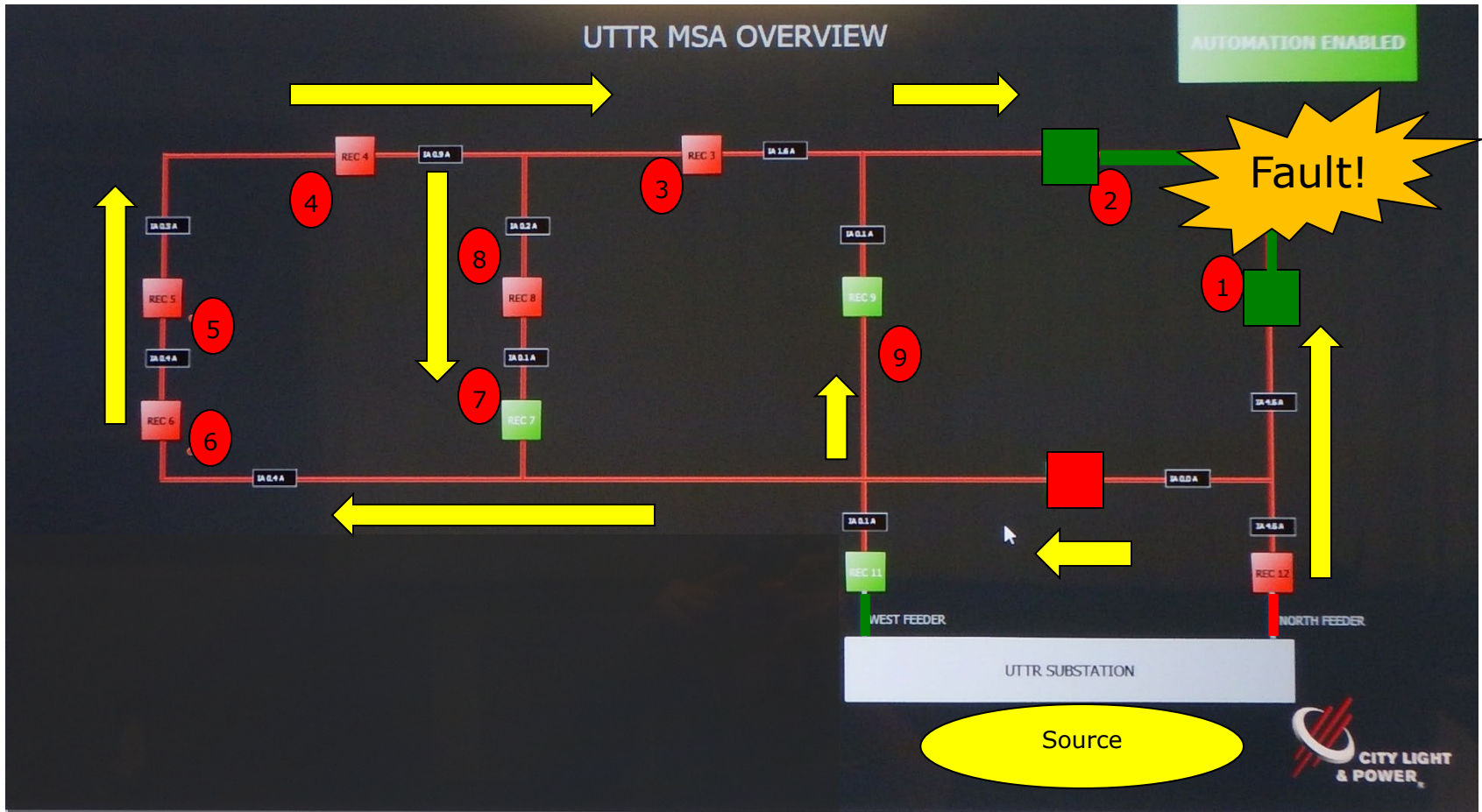
Single Line Drawing of MSA Power Platform

- Nine (9) platforms replace 50+ transformers
- Each platform fed via tri-pole layout w/recloser





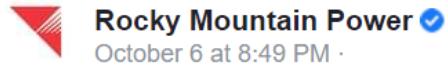
Reconfigured Power Flow Thirty Seconds Later...



“Put the TEST back in UTTR”

Save at Little Mountain

- On 10/6/21 an evening storm knocked out the commercial power feed to Little Mountain Test Annex in Ogden Utah. Commercial utility reported fire on a pole.
- CLP automation system detected the outage, started the emergency generator and transferred power.



October 6 at 8:49 PM ·

We are aware of the power outage impacting approx. 2,800 customers in Weber County, UT. Crews have been dispatched to investigate and repair. Currently the ETR is 12:30 am. To report an outage, text OUT to 759677 or visit rockymountainpower.net/outage



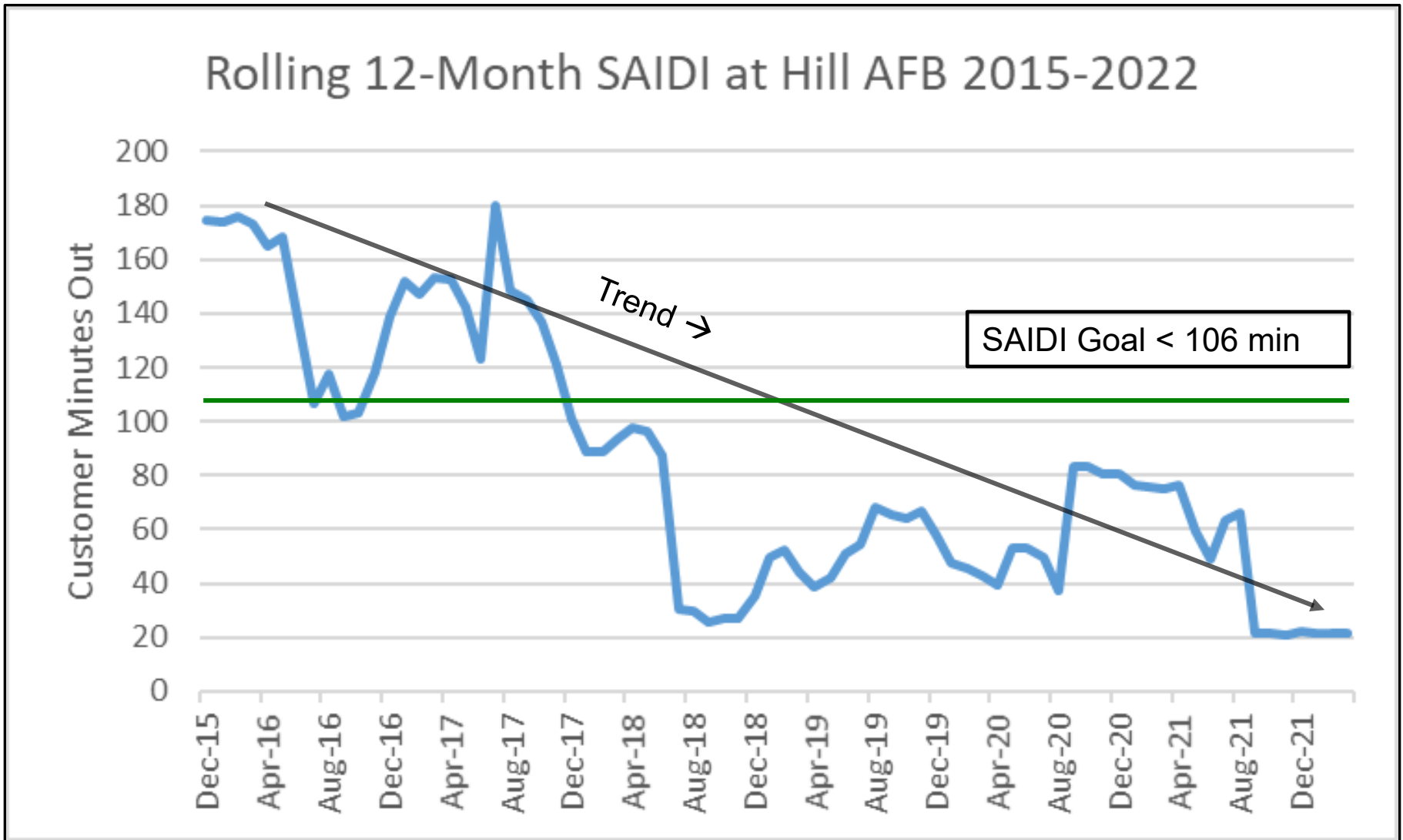
Weather and infrastructure increase risk of commercial power outages

- CLP's automated system alerted crew & leaders.
 - Remote status checks allowed frequent monitoring.
 - CLP generator powered LMTA for over 16 hours.
 - No LMTA power outage was ever reported.
-
- Automation averted a power outage.
 - Properly maintained system provided continuity of power flow & mission support

- Minimize outage impacts
 - Old: Squirrel takes out 90 buildings
 - New: Self aware system finds problem & reconfigures
- Real time alarms with trouble location and guidance for responding crew members
- Now few (if any) buildings down until crew arrives

Automation Improves Resilience

Results! CY 2021 Reliability



Trend is reduced customer-minutes out...January 2022 SAIDI = 21 min

Hill AFB ASAI 99.XX%



Trend is increased power availability for the mission

- Reliability target for SAIDI: < 106 (7,700 cust. min/month)
- Target for ASAI: Four 9s = 99.99% reliability

Year	Unsched Outages	Customer Minutes	Rolling ASAI	Rolling SAIDI
2015	43	153,027.00	99.9667	174.89
2016	42	121,700.00	99.9736	139.09
2017	42	88,714.00	99.9807	101.39
2018	21	31,058.00	99.9932	35.49
2019	32	50,375.00	99.9890	57.39
2020	25	70,588.00	99.9847	80.55
2021	12	19,530.00	99.9958	21.95

Our Tech and Our O&M/Recap is Working!

- Infrastructure alerts when attention is needed
- Enable system to discover problems early
- Apply tech to improve system understanding
- Automate systems where it makes sense
- Prepare systems for future microgrids

Smart System Heals Itself

- Keep a list of energy resilience resources
- Adopt best practices
- Use System Asset Management
- Track performance metrics
- Share your stories
- Resilience starts at home. Be a resilience beacon...
 - Where are your flashlights?
 - How much water and food do you store?
- Stay in touch with communities of interest like SAME Resilience!
 - Another list of resilience resources on SAME COI website
 - Look for nexus in other communities of interest

Pro Tip: Schedule time each week to review activity on [SAME.org](https://www.same.org)

Customize Your Own 72 Hour Kit

Category	Survival Minimum	Essential Additions	Convenience Additions	Luxury Additions
1. Food/Water	Food, None (Adult) Water: 2C/day: 2Q/person Water Purification & Instructions	Food, Any (Unbreakable packages) Water: 1 Gal/person Per Day	Food Ready-To-Eat Water: 5-10 Gal/person Pet Food Special Diet Foods	Luxury Foods 50-100 Gal/family Salt, Sugar, Spices Multiple Purification Methods
2. Shelter/Bedding	Space Blanket	Space or Bivy Bag Umbrella	Ground Cloth (Sheet Plastic) Blankets (Wool or Fleece) Earplugs (Foam-For Public Shelter)	Tent, Trailer Sleeping Bags Closed Cell Foam Pads
3. Clothing	30 Gal Garbage Sacks 1 Gal, 1 Qt Plastic Bags (plain not zip)	Warm, Layers (Fleece/ Wool) Wool Cap Warm, Dry, Sturdy Footwear	Rain Jacket/Pants Extra Socks, Underwear Gloves	Complete Change of Clothes Sewing Kit, Shoelaces, Safety Pins Laundry Soap
4. Heat/Light	Matches (Waterproof)	Flashlight w/Batteries Cooking Heat (Sterno or Solid Fuel)	LED Headlamp w/Batteries Flint And Steel Hiker's Stove/Fuel	Multiple Fuel Source Emergency Generator Battery Lantern Camp Stove w/Fuel Space Heater w/Fuel
5. First Aid	Basic Kit First Aid Manual Bandanna		Expanded Kit	EMT Kit Fire Extinguisher (A-B-C) Insect Repellent, Sunscreen
6. Sanitation	Hand Sanitizer (double bagged)	Toilet Paper Trowel Plastic Bags, Ties Soap(Hand/Dish) Feminine Hygiene Diapers (If Needed) Moist Towelletes	Plastic Bucket w/Tight Lid Large Plastic Bags Toilet Seat Disinfectant, Bleach Hand Towel, Cloth Toothbrush, Paste, Floss Paper Towels	Port-A-Potty Newspaper Deodorant Shampoo Shaving Kit Nail Clippers Comb, Brush
7. Communication	Card w/Phone Numbers	Contact Plan Family Pictures. W/Names Extra Phone Charger Cable	Whistles Paper and Pencil (Not Pen)	Flares, Light Sticks Map, Compass
8. Personal/ Valuable	Personal Medication (Rotate)	Cash: Small Bills and Coins	Copies of Important Papers Valuables Watch/Clock	Mirror (Metal) Infant/Elderly Needs Sunglasses, Extra Glasses
9. Tools/Utensils	Sharp Pocket Knife Functional Container or Pack for Kit	Paper Cups, Plates Plastic Forks, Spoons Aluminum Foil Paper Towels Rope/Cord/String	Manual Can Opener Skillet, Lid Cook Pot, Lid Gloves, Leather Steel Wool, Pot Scrubber Hot Pads Extra Plastic Sacks (Small)	Crescent Wrench Screwdrivers Pliers, Scissors Baling Wire, Duct Tape Solar Still Shovel Axe, Saw, Whetstone Crowbar, Hammer
10. Morale		Radio W/Batteries Dust Masks	Hard Candy Toys, Games, Puzzles Paper, Crayons Emergency Survival Book	Journal, Pencil (Not Pen) Hobbies, Crafts Magazines, Books Scriptures

- Pull the Plug exercises make it more realistic
 - Generators don't start
 - Here's a surprise: people don't maintain our UPS systems!
- Energy funding leaning less toward “payback” and more toward increasing resilience
 - Tough to quantify or measure
 - Win-win: savings and resilience



- Fleet electrification
- Energy storage
- Nuclear energy

Thank You

Thank you for letting us share our story with you.



GREAT BASIN INFRASTRUCTURE RESILIENCE TEAM

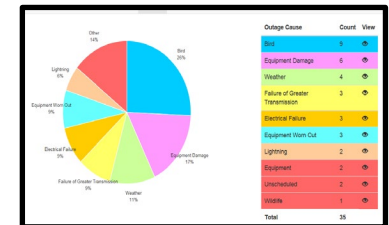


Discussion/Questions



Narrow the focus: Measuring Electrical Performance

- The Mission: Deliver Max minutes to customers
 - All key metrics depend on this number
 - Reliability is about power being available
- SAIDI = Cust Minutes Out/ Total # of Cust
 - Average minutes out in period for a random customer
- CAIDI = Cust Minutes Out/ # of Cust Out
 - Average minutes until service restored
- ASAI = Minutes Delivered/Minutes Promised
 - How close to perfection the system got



- Sensitive material in Missile Storage Area
- Facility systems need reliable power
- UTTR in remote section of Utah
 - Nearest homes 40+ miles away
 - Less “eyes-on” than average installation
 - Single commercial power feed
 - Emergency genset at substation as alt power source
- Historic problems w/UTTR emergency genset
- Animal-caused outages in area of Munitions Assembly, Maintenance and Storage (MAMS1)

“On a rattlesnake speedway in the Utah desert...”

- Presidential Policy Directive 21 Definition in 2013
 - Ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions”
 - “Includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.”
- “Mitigation, response and recovery activities contribute...”
- Why: frequency of extreme weather events increasing
- And then?: Use tech, policies, information, & stakeholder engagement to strengthen energy sector resilience