Elements of a National Grid Resilience Architecture

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Five elements at Regional, City, and Local levels

- Protect against power system failure modes: unstable flows and uncontrolled dynamics

1. Real-time corrective dispatch (regional)
2. Segmented Regions
3. Pre-Planned Isolated Enclaves (city-scale)
4. Microgrids (local)
5. Deployable Lifeline Systems (local)
Anonymized Excerpt of ISO-NE System: Major Contingency

Major N-6 contingency event
- 2.1 GW of generation lost
- Four major ties lost

Legend
- Faulted bus or generator
- Faulted breaker
- Power generation plant
- Connection to rest of network
- De-energized bus
- Energized bus
- Normally-open breaker
- Normally-closed breaker
Power Flow Optimization Results: 
Best Case Outage Scenario

- 200 MW blackout
- Potential cascading outage
  - 6 buses with voltage violations
RARES Optimization Algorithm Results
Voltage Adjustment Guidance to Operators

Found “needles in the haystack”
- Adjust voltage on only 5 buses up to 5%
- Increase one generator by 93 MW
Minor Adjustments Prevent a Blackout

- MIT-LL’s RARES results solved on the ISO-NE power flow software

Rebalanced Load with RARES Adjustments (MW)
National Grid Resilience Architecture Vision

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- Protect against power system failure modes: *unstable flows and uncontrolled dynamics*

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Typical Outage Events – 90 MW Site
Using Available Fuel Reserves

Architecture #24 assets:
- Microgrid
- Central & building generators
- Islandable solar

Architecture #9 assets:
- Microgrid
- Central generators
- Islandable solar

Architecture #22 assets:
- Central & building generators
- UPS
- Grid-tied solar

Unserved Energy (MWh)

Lifecycle Cost ($/kWh)
The correct systems could make sites resilient to long-duration outages

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Internet Connectivity as a Proxy for Power Status

Hurricane Irma: Florida

Estimated from internet connectivity
** EXPERIMENTAL **