

PPL EU Grid Resiliency

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PPL Electric Utilities



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PPL Transmission System Profile

T&S Assets	69 kV	138 kV	230 kV	500 kV	Total
Transmission Line Mileage	3,230	260	1,241	440	5,171
Substation Count (High-Side Voltage)	3	3	46	12	64

Generators in Footprint
71
Total MW
11,654



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Survivability - 3 Main Areas

Security:

- Led by Asset Management & Engineering, focus:
 - NERC Compliance
 - Evolving technology and capability
- Reliability:
 - Transmission Planning criteria & Asset Performance
- Resiliency:
 - Black Sky Group formed
 - Planning
 - Preparation & Drill
 - System Performance



Security Strategy Goal

- Establish the business strategy for Physical Transmission Substation Security
 - Reduce security risk to transmission subs
 - Ensure system resiliency
- Develop specific application criteria
 - Define impact level categories
 - Define system wide strategies
 - Define solutions and applications based on impact
- Risk Based Approach



Threat vs. System Impact Definitions

	System Impact								
	CIP-002 Category	Low				Medium		High	
	PPL Defined Impact	Minimal Impact	Small Impact	Moderate Impact	Modest Impact	Large Impact	Major Impact	Critical Impact	
Threat Class & Probability	Unthinkable (never before) (large scale)	<i>Consider assuming risk and only doing most cost effective mitigation</i>						<i>Reduce criticality and prepare response/recovery as possible. Rely on "National Security Defense" for deterrence</i>	
	Uncommon (every couple years)								
	Common (multiple per year) (small scale)	<i>Mitigate as practical with available solutions</i>				<i>Mitigate as practical with available solutions + Take additional steps to reduce consequences and ensure recovery and response is adequate</i>			

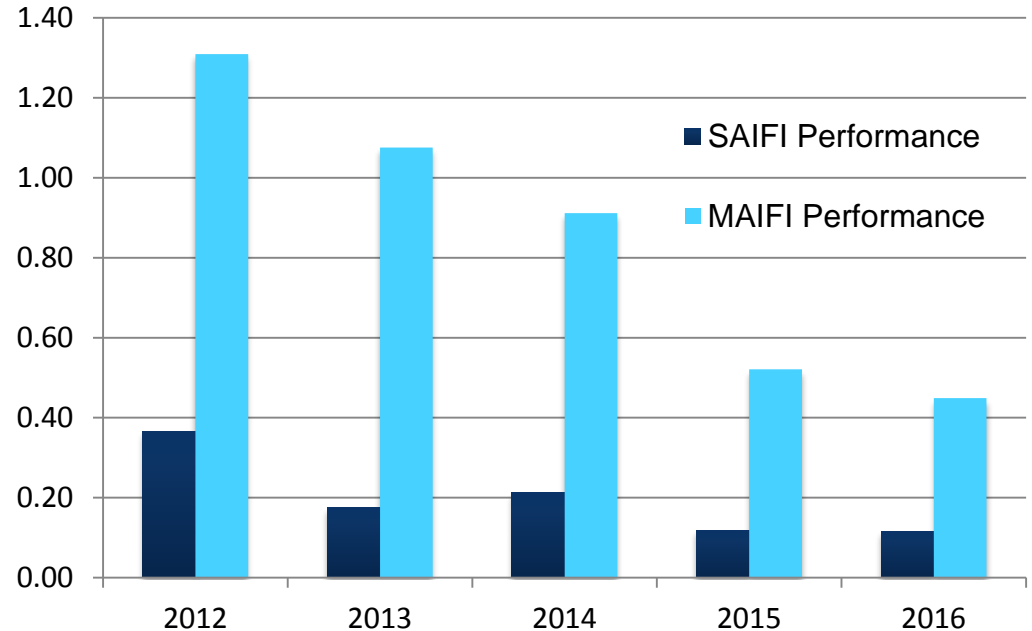


Reliability Improvements

Improvements made since 2012

T&S Assets	Total Over Past 5 Years
New/Rebuilt Transmission Lines (mileage)	315
Replaced Wood Poles	~2,500
New/Rebuilt Substation Yards	12
New/Replaced Transformers	39
New/Replaced Circuit Breakers	367

T&S SAIFI and MAIFI Performance



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Initiatives Around Resiliency

- Reliability
 - Standards around System Hardening & Security
 - Improved Asset Performance
- Recoverability
 - BES Operational Flexibility
 - Spare & Mobile Strategy
- Survivability
 - BES System Sensitivity Analysis
 - Black Sky Drills & Preparation (Playbook)



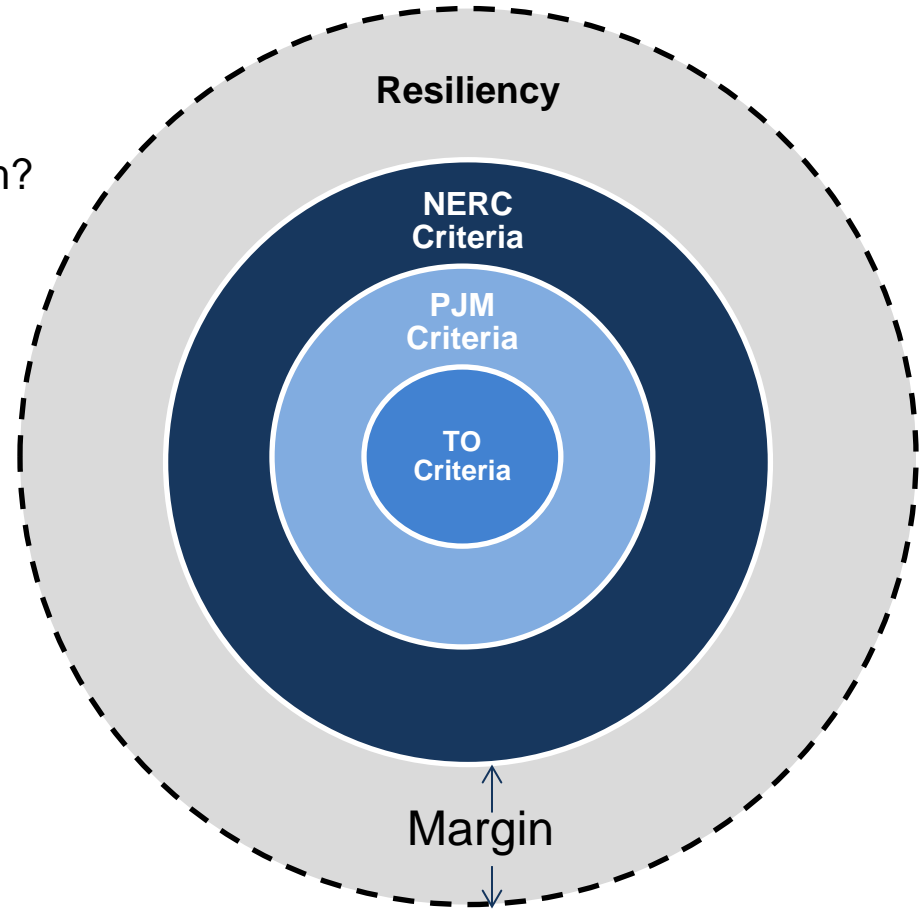
Understanding System Margin

What if a bulk substation is lost?

- What is the stability impact on the system?
- How close is the system to becoming unstable?

Do we understand the level of resiliency you can survive?

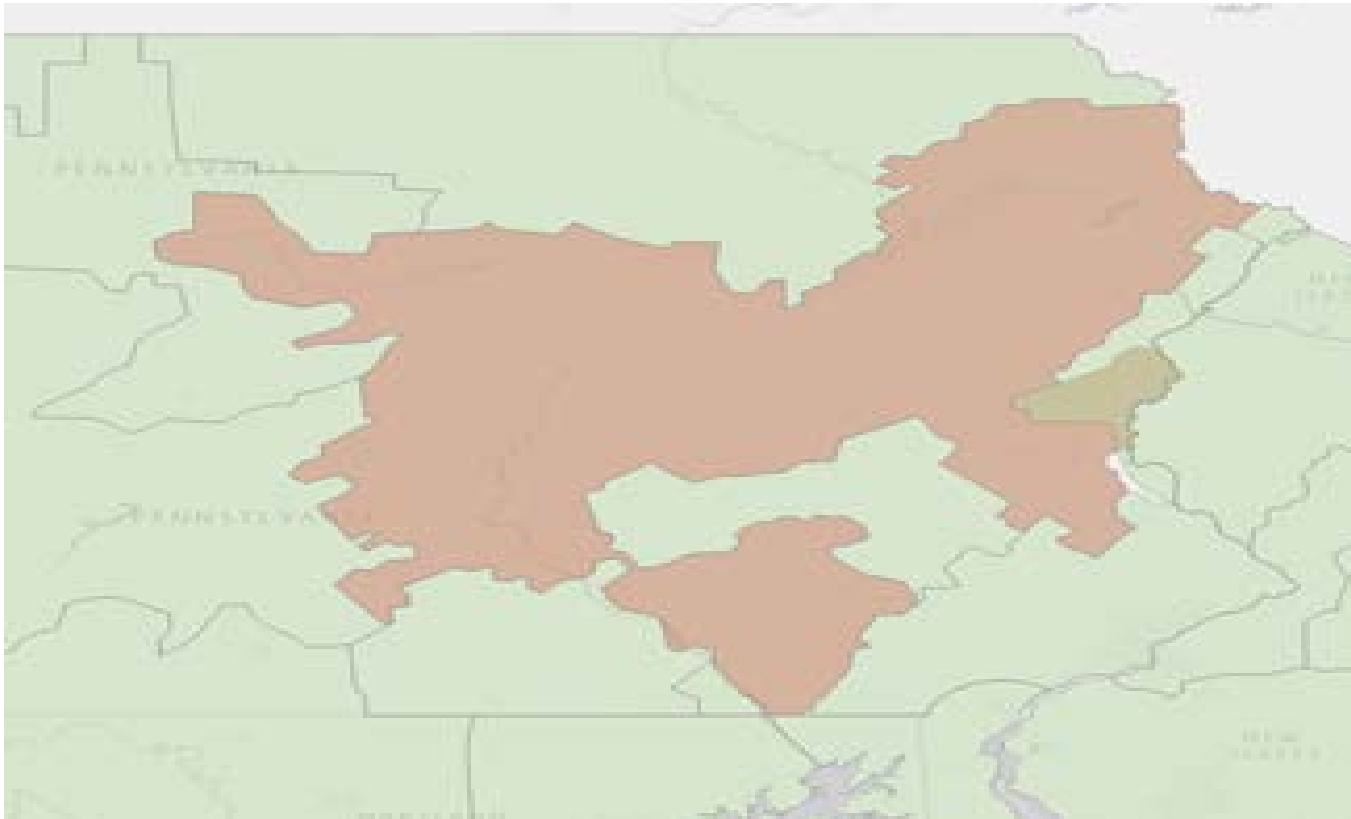
- Loss of a single substation (Stability)
- The effect of a loss of a major outlet



Black Start Limitations

What if an extreme event led to a blackout and loss of your black start paths?

- Current Black Start methodology assumes all equipment is in-service with no damage to transmission or generation equipment
- Does not provide redundancy or viable alternative restoration paths in the event a Black start unit isn't available



Today's Black Start process meets the minimum requirements.

How do we address Black Start for a resiliency type event?



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Black Sky Preparation

- Cross Functional Team formed
 - Emergency Response
 - Engineering (Transmission & Distribution)
 - Operations (Transmission & Distribution)
 - Security
 - Facilities
 - Customer Service
- Planning
 - Actions developed to respond to Black Sky events
 - Engagement of state and local authorities
 - Play books being drafted
- Preparation
 - Table top drills planned for later this year



Next Steps

What can we do to improve Resiliency in PJM?

- Develop sensitivity analysis for extreme Bulk Electric System events
 - steady state & stability Reviews
- Revise Black Start methodology and requirements to include:
 - Black Start options – Including additional flow paths
 - TO ability to allow dispatch of local generation
- Develop a process and forum to address resiliency initiatives and projects
 - Ability to discuss sensitive TO criteria and results around resiliency

