Review of ATC Proposed 15947 Waupaca Area Storage as a Transmission-Only Asset (SATOA) Project

Discussion Overview

Objective:

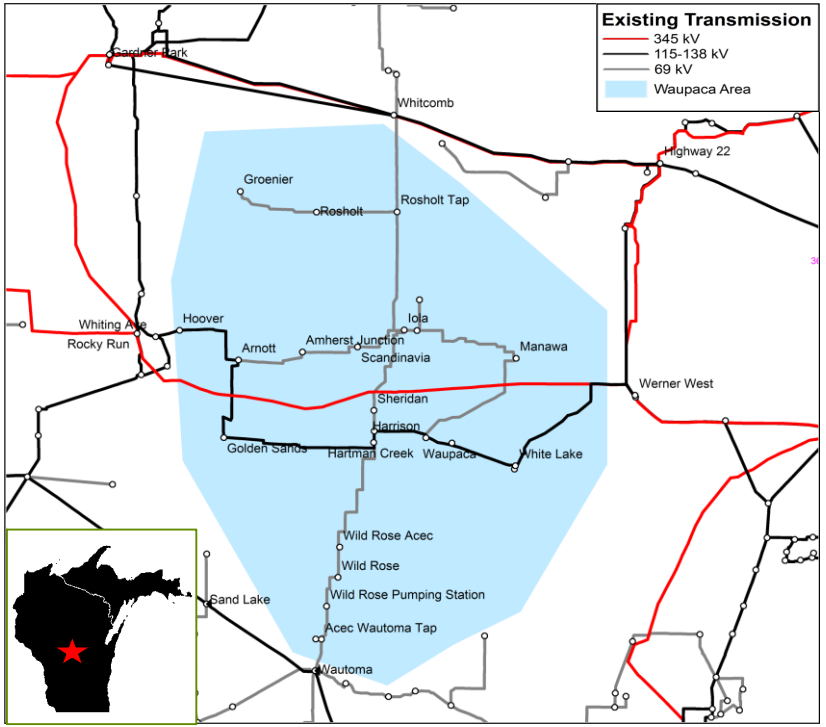
- Present MISO's technical review results of ATC proposed project 15947 SATOA and alternatives

Key Takeaways:

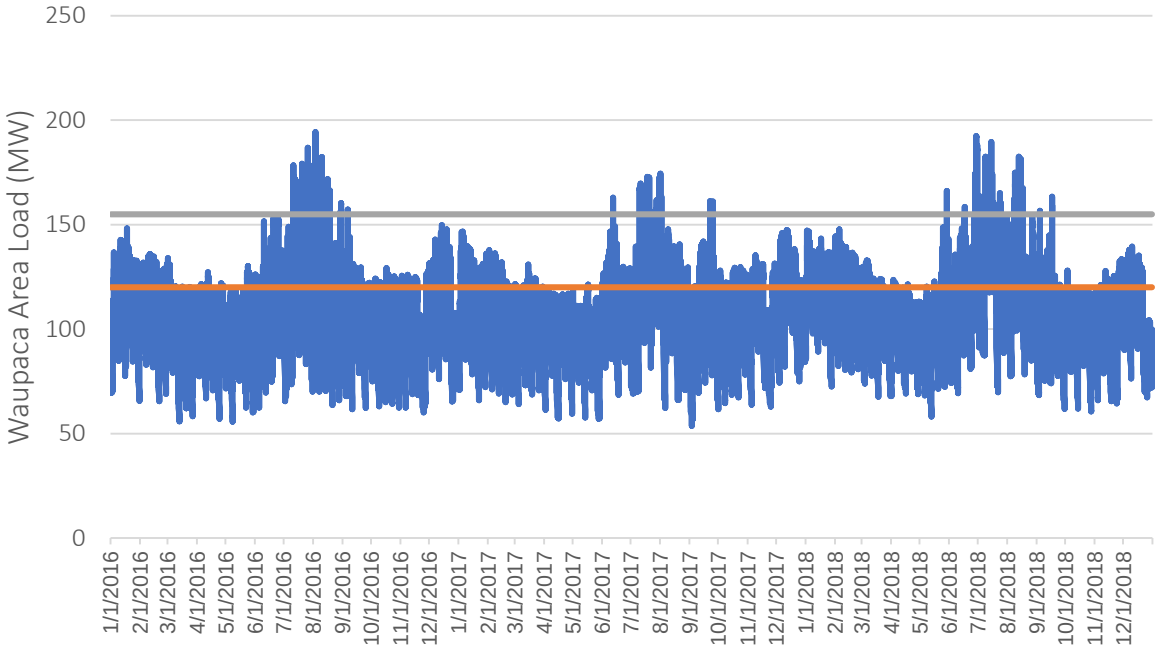
- Proposed project and alternatives aim to increase local area reliability and provide operational flexibility in Waupaca area
- Comparable technical performance are observed among all solution alternatives to address identified reliability risks
- MISO is evaluating life cycle cost comparison among solution alternatives

Multiple-outage conditions (planned or forced) put Waupaca area of Wisconsin reliability at risk

- The area of concern involves a local 69 kV system supported by a nearby multi-segment 115/138 kV transmission line.
- When both ends of the 115/138 kV supply line are out of service (planned or forced) the local loads cannot be sustained.
- Existing solution is to utilize an operating guide (ATC Reference Guide) after the first outage, to sectionalize 69 kV system at certain load levels, creating radially served loads.
- This allows the loads to be served after the second contingency, but places many loads at risk of loss for a single failure
  - This reference guide reduces maintenance opportunities and increases the amount of load at risk in the area



The proposed project aims to reduce loads at risk of loss up to 155MW load level, capturing over 90% of load levels historically experienced



Historical load Level	Average % of days over the past 6 years (2012-2018)
> 155 MW	6%
115-155 MW	64%
< 115 MW	30%

MISO Reliability Assessment Overview

MISO Reliability Assessment Overview

- MISO conducted contingency analysis against a selected set of multiple-outage events to evaluate ATC proposed project and alternatives
- Considerations include impacts of solutions on load service risks and system reliability performance
- Solution alternatives considered include a wide range of options
  - Battery storage only solutions
  - Hybrid storage and traditional wires solutions
  - Traditional Wires only solutions
- Life cycle costs are being compared among solution alternatives to account for different useful life of solutions
- Study Criteria: NERC TPL-001-4 and Applicable Local TO Planning Criteria

MISO Reliability Analysis Scope and Assumption

Scope	Description
Study scenario	Waupaca Area scaled to 155 MW load
Study timeframe	5 year out
Power flow models	2024 Shoulder 40% Wind, 2024 Shoulder 90% Wind
Contingencies	P6 and [Prior Outage + P12] in Waupaca Area
Monitored Elements	69kV and above facilities in Waupaca Area

MISO Reliability Analysis Model Development

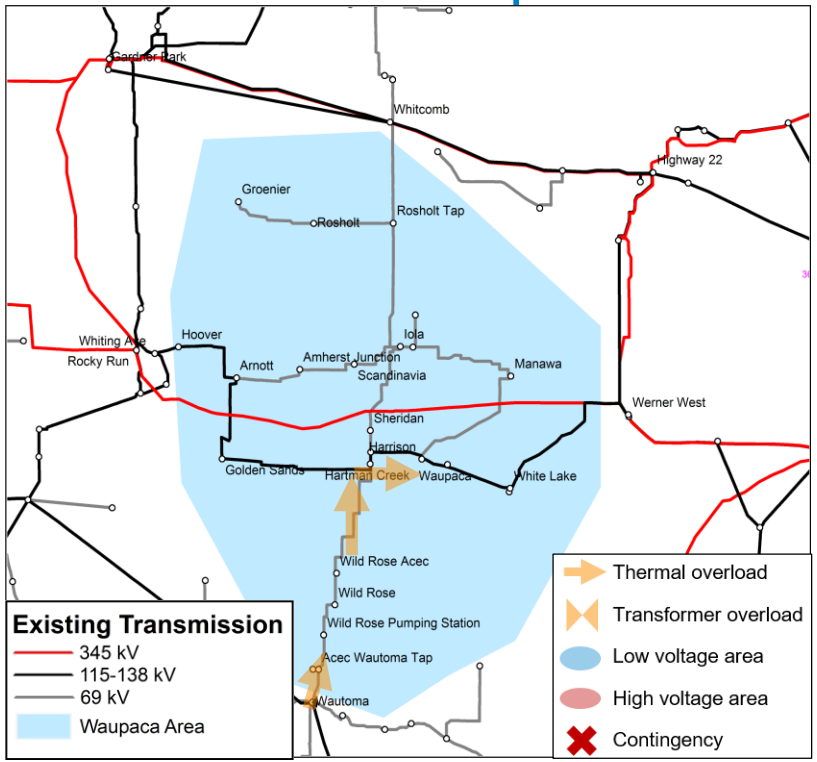
Use MTEP19 models as starting point

- Base case 2024 Shoulder peak with 40% Wind
- Sensitivity case 2024 Shoulder peak with 90% Wind

Noteworthy model updates

- Adjust Waupaca area load to 155 MW for shoulder peak cases
- Adjust and lock LTC transformers and capacitors in prior-outage cases in preparation for worst contingencies

Multiple-Outage conditions result in both thermal and voltage violations in Waupaca area



Top Thermal Violations			
Monitored Facility	**Voltage Level (kV)**	**Contingency Category**	**Max Loading (%)**
Wautoma – ACEC Wautoma Tap	69	P6	139.5%
Harrison Tap - Harrison	69	P6	111.5%
Wild Rose Tap – Harrison Tap	69	P6	109.9%

Top Voltage Violations			
Substation	**Voltage Level (kV)**	**Contingency Category**	**Voltage Violation (pu)**
Amherst Jct	69	P6	0.767
Arnott	69	P6	0.750
Arnott	138	P6	0.769
Harrison	69	P6	0.766
Harrison North	69	P6	0.766
Hoover	115	P6	0.766
Hoover	138	P6	0.767

When system is sectionalized after a prior outage, Up to 114 MW of load is at risk of loss due to next contingency

First Contingency	Load Group Served Radially after first contingency, utilizing ATC reference guide to sectionalize 69kv system			
	Group A	Group B	Group C	Group D
Whiting Ave – Hoover 115 kV	114 MW	--	23 MW	19 MW
Hoover – Arnott 138 kV	89 MW	25 MW	23 MW	19 MW
Harrison – Waupaca 138 kV	43 MW	71 MW	23 MW	19 MW
Waupaca – White Lake 138 kV	18 MW	96 MW	23 MW	19 MW
White Lake – Werner West 138 kV	--	114 MW	23 MW	19 MW

SATOA siting and sizing

MISO considered and optimized SATOA siting locations to address system reliability needs

Physical Site Selection	• Select a list of buses that could serve as viable siting locations by assessing connectivity and physical limitations
Reactive Needs	• Identify minimum reactive injection required to maintain voltage at each site
Real Power Needs	• Calculate each site's minimum real power injection required to effectively mitigate thermal overloads
Optimizing Sites	• Rank sites based on minimum reactive and real power injection required

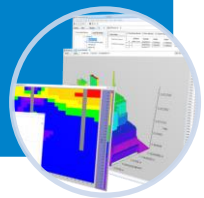
MISO considered and optimized SATOA siting locations to address system reliability needs (cont.)

- Identify location of a list of transmission constraints
  - Substations must be within Waupaca Area
  - Substation must be downstream of transmission sources
- Select buses which appear to be networked substations

Bus Location

- Use PSSE to identify minimum reactive injection at each site to maintain 0.90 p.u. post-contingent voltage
- Use TARA to calculate site DFs against thermal constraints, and calculate minimum MW injections for each site to address thermal overloads

MVAR and MW Needs

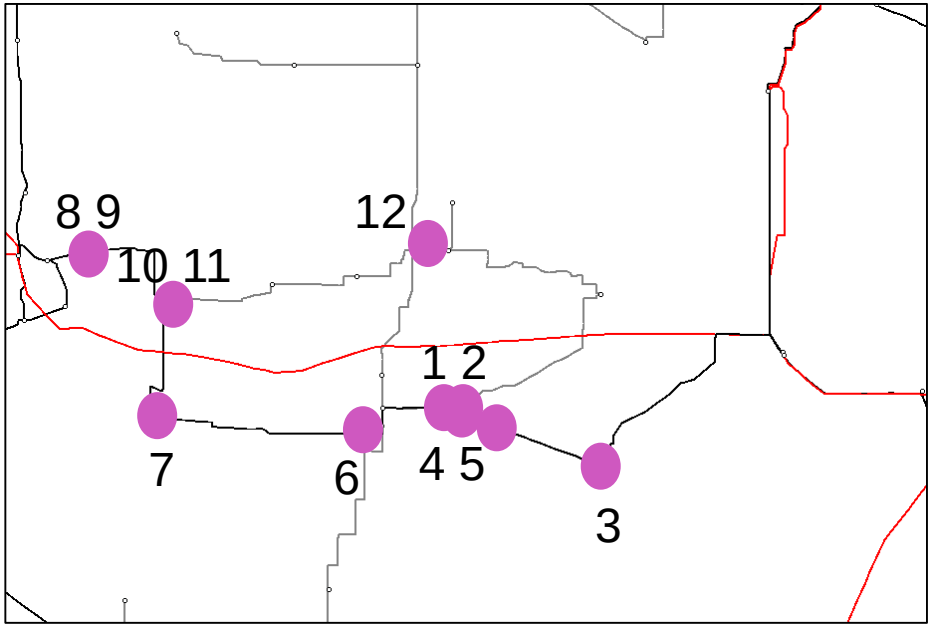


- Rank sites based on minimum reactive and real power injection required
- Select optimized siting locations for solution alternatives evaluation

Optimize Siting

The most effective site is near the Harrison 69 kV substation, but most 138 kV buses between Arnott and Waupaca perform similarly well

Map #	Bus station Name	MVAR Need	MW Need Harrison Tap – Wild RoseTap 69kV	MW Need Harrison – Harrison Tap 69kV
1	Harrison 69 kV	16	5.5	3.4
2	Harrison North 69 kV	16	5.5	3.4
3	White Lake 138 kV	16	5.9	3.6
4	Harrison 138 kV	16	5.9	3.6
5	Waupaca 138 kV	16	5.9	3.6
6	Hartman Creek 138 kV	16	6	3.6
7	Golden Sands 138	16	6.2	3.7
8	Hoover 138 kV	16	6.3	3.8
9	Hoover 115 kV	16	6.3	3.8
10	Arnott 138 kV	16	6.3	3.8
11	Arnott 69 kV	17	7.1	4.3
12	Iola 69 kV	19	8.4	5.1

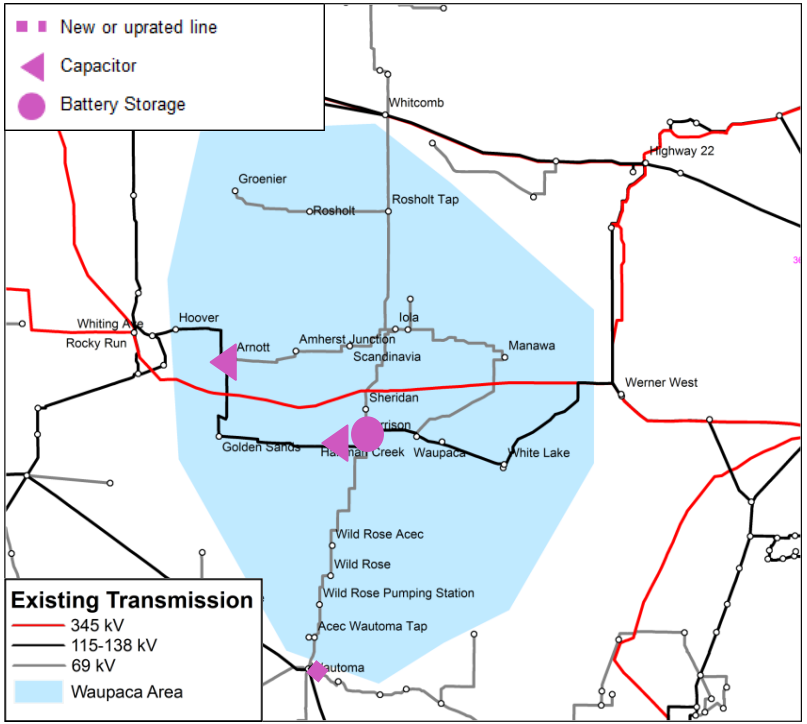


The most limiting thermal overload on Wautoma – ACEC Wautoma Tap 69 kV will be mitigated by upgrading the Wautoma 69kV bus with 94MVA emergency rating at a very low cost.

Evaluation Results of Solution Alternatives

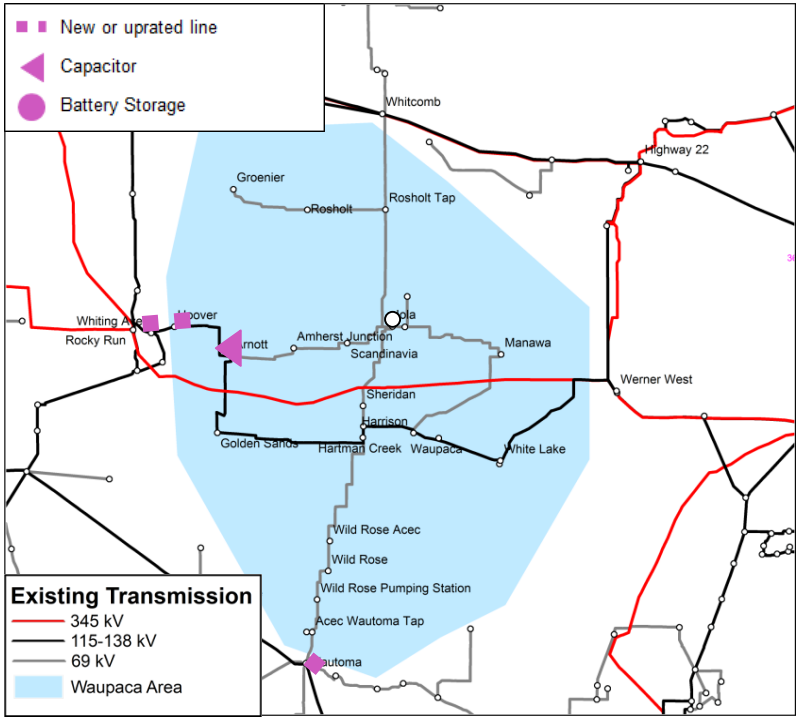
ATC proposed Waupaca Area Energy SATOA Project 15947

- **Other – Local Reliability**
- **Project description**
  - Install 2.5 MW/5MWh battery at Harrison North 138 kV
  - Install capacitors at Arnott (8 Mvar) and Harrison North (6 Mvar) 138 kV
  - Upgrade Wautoma 69 kV bus
- **Estimated Cost:** $9.1 M (2019$)
- **Expected ISD:** December 31, 2021
- **Target Appendix:** A in MTEP19
- Other considerations:
  - Fewer public impact on ROW
  - 2-hour discharge period for battery



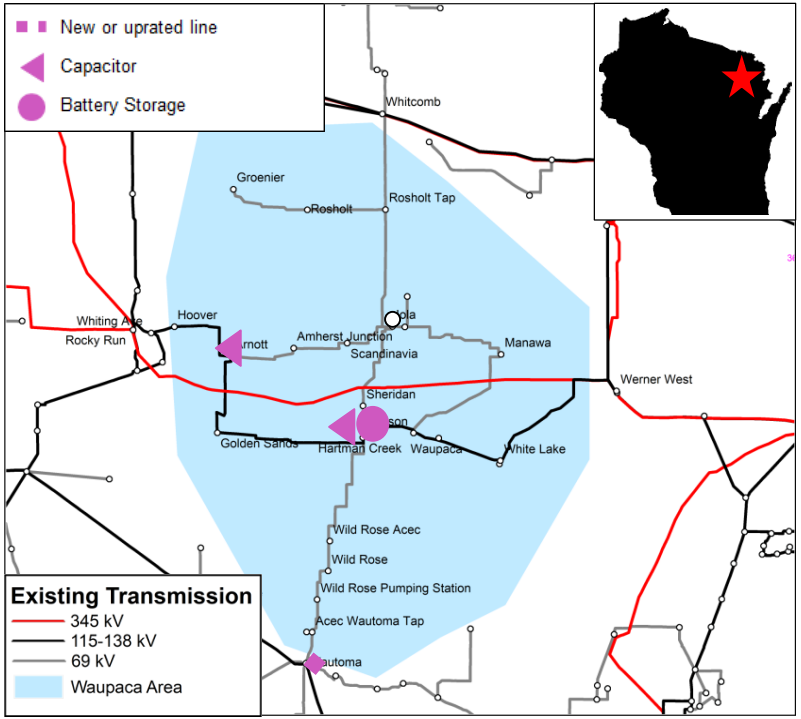
Alternative 1: Traditional Wires Solution Alternative to the Waupaca SATOA project evaluated

- **Project Description:**
  - Rebuild Whiting Avenue – Hoover 115 kV as double circuit,
  - 10 Mvar capacitor at Arnott 138 kV,
  - Upgrade Wautoma 69 kV bus
- **Estimated Cost:** $12.4M (2019$)
- **Expected ISD:** December 31, 2021
- Other considerations:
  - Need for expanded ROW
  - No online time restrictions



Alternative 2: Non-wire Alternative to the Waupaca SATOA project evaluated

- **Project Description:**
  - Install 5 MW/10 MWh battery at Harrison North 138 kV,
  - 6 Mvar capacitors at Arnott and Harrison North 138 kV,
  - upgrade Wautoma 69 kV bus
- **Estimated Cost:** $10.4M (2019$)
- **Expected ISD: December 31,** 2021
- Other condierstions
  - Fewer public impact on ROW
  - 2-hour discharge period for battery



Comparable preliminary technical performance among proposed solution alternatives to address Waupaca reliability thermal overloads

Monitored Facility	Event Type	No Project	Proposed	Alternative 1	Alternative 2
		Max loading %	Max loading %	Max loading %	Max loading %
Wautoma - ACEC Wautoma Tap 69 kV	P6	143%	93%	< 90%	93%
Wild Rose Tap - Harrison Tap 69 kV	P6	115%	98%	< 90%	98%
Harrison - Harrison Tap 69 kV	P6	114%	98%	< 90%	97%

Preliminary technical performance among proposed solution alternatives to address Waupaca area voltage issues

Monitored facility	Event Type	No Project Violation Count (worst voltage)	Proposed Violation Count (worst voltage)	Wires Alt Violation Count (worst voltage)	5MW ES Violation Count (worst voltage)
Arnott 138 kV	P6	12 (0.7691)			2 (0.8998)
Arnott 69 kV	P6	13 (0.7498)			3 (0.898)
Golden Sands 138 kV	P6	10 (0.7722)			2 (0.8993)
Harrison 138 kV	P6	10 (0.781)			
Harrison 69 kV	P6	10 (0.7659)			1 (V drop)
Hoover 115 kV	P6	10 (0.7668)			2 (0.8978)
Hoover 138 kV	P6	19 (0.7655)			4 (0.8966)
Harrison North 69 kV	P6	10 (0.7655)			1 (V drop)
Harrison Tap 69 kV	P6	8 (0.7839)			1 (V drop)
Hartman Creek 138 kV	P6	10 (0.7851)			2 (0.8991)
Waupaca 138 kV	P6	8 (0.8787)			
White Lake 138 kV	P6	8 (0.8763)			
Wild Rose 69 kV	P6	2 (0.8795)			
Wild Rose Tap 69 kV	P6	3 (0.8599)			

A variety of wires and non-wire solution alternatives are being evaluated to address reliability needs in Waupaca area

	Wire Solution	Non-Wire Solutions	
Solution Considered	**Alternative #1** Rebuild Whiting Avenue – Hoover 115kV as double circuit, install 10MVAR capacitor at Arnott 138kV substation and upgrade Wautoma 69kV bus	**Alternative #2** Install a 5MW/10MWh battery at Harrison North 138kV substation, and a 6 MVAR capacitor at Arnott 138kV and a 6 MVAR capacitor at Harrison North 138kV substation*	**Proposed Project** Install a 2.5MW/5MWh battery at Harrison North 138kV substation, and a 8 MVAR capacitor at Arnott 138kV and a 6 MVAR capacitor at Harrison North 138kV substation*
Reliability Performance	Address identified needs	Address identified needs	Address identified needs
Estimated Capital Cost ($2019)**	$12.4M	$10.4M	$9M
Overall Comparison	Comparable performance Most expensive** Need for expanded ROW No online time restrictions	Comparable performance Less expensive** Fewer public impacts on ROW 2-hour discharge period	Comparable performance Least expensive** Fewer public impacts on ROW 2-hour discharge period

* Both non-wire solutions require the same Wautoma 69kV bus upgrade as in wires solution

** life cycle cost comparison is currently being evaluated and will be reported at the 3rd SPM

SATOA modeling and control

The SATOA is modeled as off-line except in the N-1-1 condition and is operated as a post contingency automatic action

Base case system intact

- Battery is off-line, or
- May be used to regulate voltage as 0 MW, with Mvar output

Multiple outage conditions

- System adjustments allowed after first contingency
  - Shunt capacitors and transformer tap adjustments
  - Battery device to regulate voltage limits without injecting MWs
- Battery device deployed to regulate voltage and thermal limits after second contingency

SATOA Control

- Battery operation is automated and triggered as a post contingency action to restore voltage and mitigate thermal overloads

Life cycle cost evaluation of wires and non-wire solutions

Comparative life cycle cost evaluation for wires and non-wire solutions

- Useful life estimates depending on the type of storage technology
- A 20 year useful life estimate assumed for Li-Ion battery
- A 40 year book life for conventional wire solution
- Storage components are assumed to be replaced once reaching the end of their useful life, at a 50% of new system cost
- Present values over a 40 year period calculated for cost comparison among solutions

Useful life Estimates

- Capacity of storage is upsized to account for annual degradation at a nominal 2-2.5% rate, assuming a few cycles per year for reliability
- Storage asset is assumed to have a lifecycle of 4,500 full cycles with 100% depth of discharge
- Inverter is assumed to be replaced every 7-10 years
- Battery augmentation is assumed to be every 7-8 years

Life Cycle and Degradation

Going Forward

- Continue developing life cycle cost comparison among proposed solution alternatives
- Work with stakeholders to understand technical details and evaluate any additional alternatives proposed
- Present final project justification results at the 3rd West SPM meeting scheduled for August 23, 2019

Questions?

NERC TPL Contingency Categories

TPL-001-4 Category	Description	Acceptable Mitigation		
		BES Level	Physical Upgrade Required?	Load Shed or Redispatch Allowed?
P0	System intact	EHV, HV	Yes	No
P1	Single contingency (Fault of a shunt device- fixed, switched or SVC/STATCOM is new)	EHV, HV	Yes	No
P2	Single event which may result in multiple element outage. Open line w/o fault, bus section fault, internal breaker fault	EHV HV	Yes No	No Yes
P3	Loss of generator unit followed by system adjustments + P1. No load shed is allowed	EHV, HV	Yes	Yes
P4	Fault + stuck breaker events	EHV HV	Yes No	No Yes
P5	Fault + relay failure to operate (new)	EHV HV	Yes No	No Yes
P6	Two overlapping singles (not generator)	EHV, HV	No	Yes
P7	Common tower outages; loss of bipolar DC	EHV, HV	No	Yes