AEP Needs Identification and Project Selection Overview

Presentation to PJM Transmission Replacement Processes Senior Task Force

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Audubon, PA

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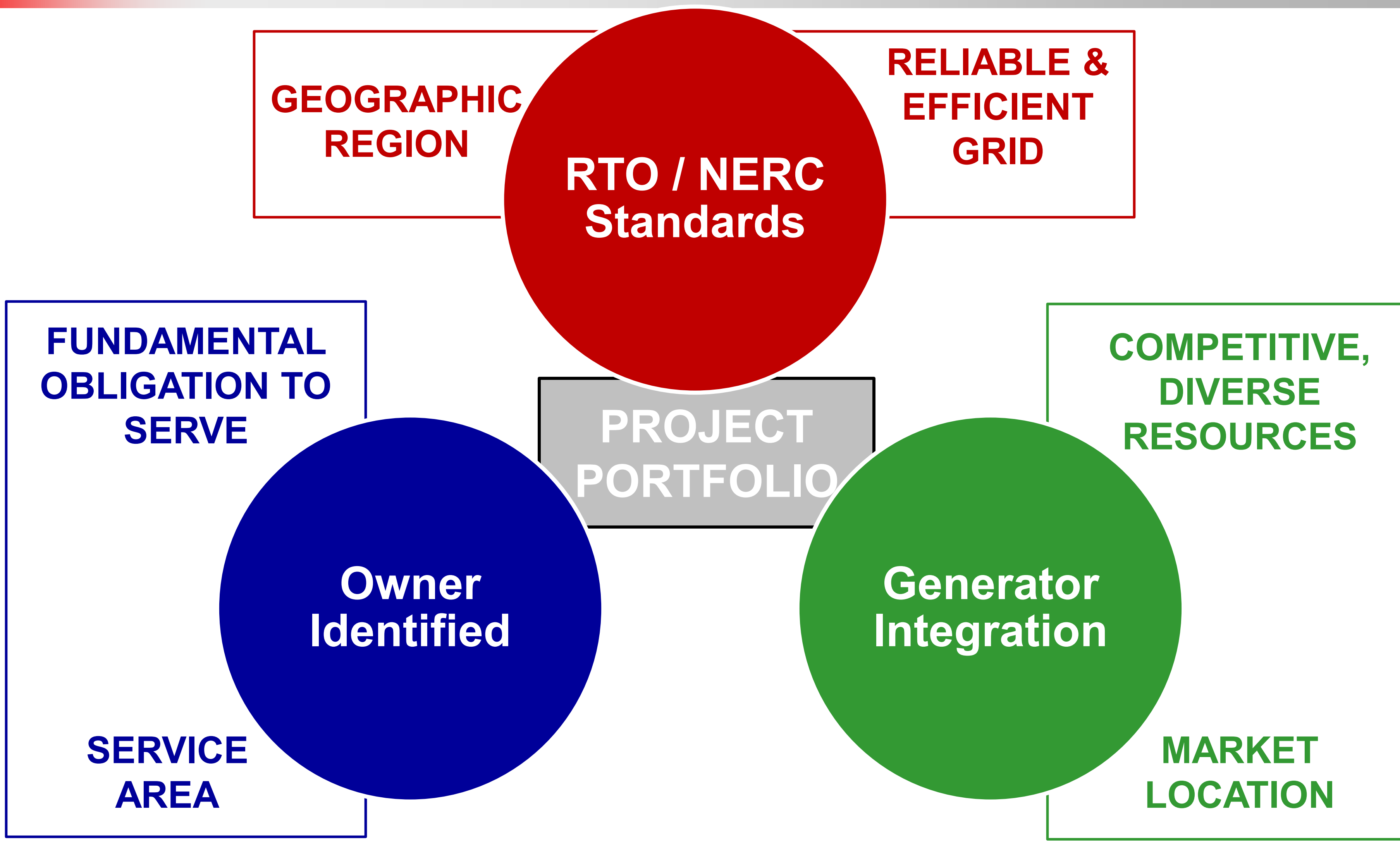
American Electric Power

Introduction to AEP Transmission

- **AEP is among the largest electric utilities in the United States**
  - More than 5 million customers
  - 200,000 + sq. mi service territory
  - 32 GW of generating capacity
  - Over 40,000 miles of electric transmission lines
  - More than 3500 substations
  - 215,000 miles of electric distribution lines

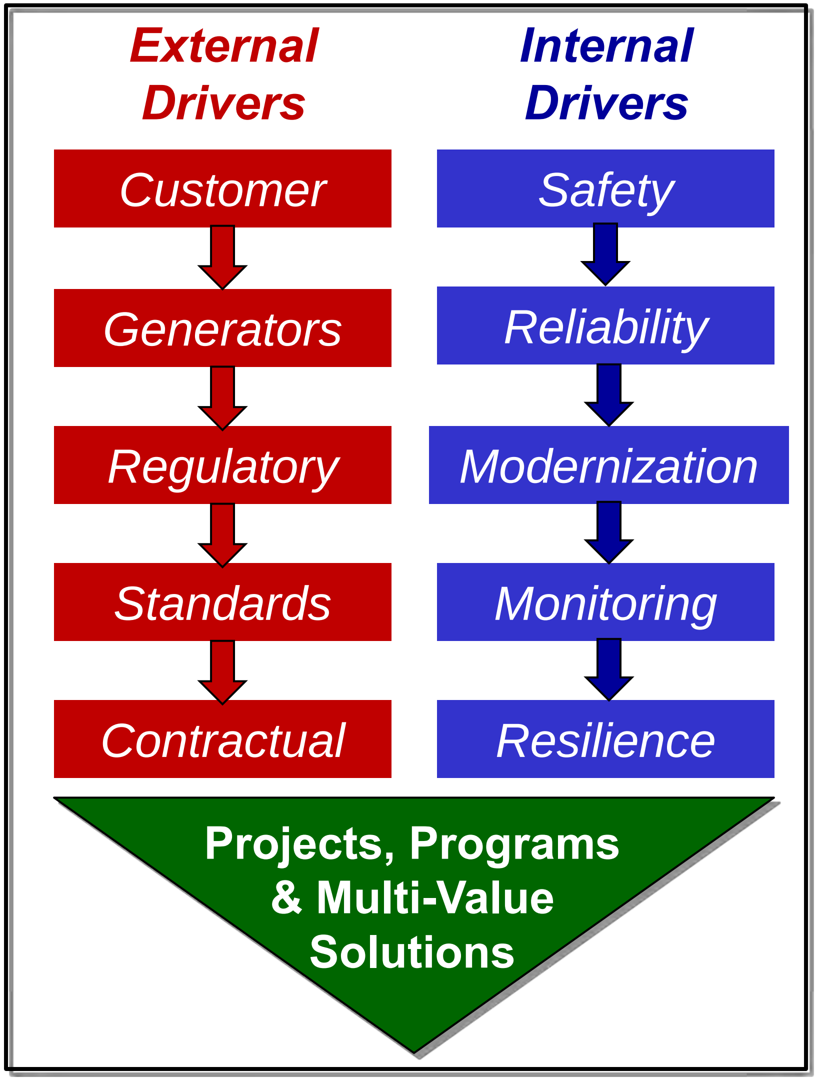
- **<u>Largest owner</u> of electric transmission in the United States**
  - Own, operate or are developing facilities in 4 RTO s
  - Operate through several transmission companies
  - Significant transmission provider, supplying:
    - ~10% of demand in Eastern Interconnection
    - ~11% of demand in ERCOT (Texas)
  - HVDC, every AC kV class including 2100-mi 765 kV
  - 13 states (AR, IN, KS, KY, LA, MI, MO, OH, OK, TN, TX, VA, WV)
  - **<u>110+ year history</u>** of low-cost, reliable transmission
  - At the forefront of transmission technology development

Transmission Project Drivers



TO Project Development

TO Identified (non-RTO) Projects



Externally Driven TO Projects

- Satisfy customer requirements
- Interconnect new generators
- Meet regulatory requirements
- Comply with NERC/industry standards
- Fulfill relocation & contract commitments

Internally Identified TO Projects

- Address safety and ratings risks
- Improve local reliability performance
- Modernize obsolete or degraded facilities
- Monitor and mitigate system/asset risks
  - SCADA, PMUs and operator awareness
  - Asset health monitoring and analytics
  - Data and telecommunications improvements
- Improve grid resilience/mitigate risks
  - Natural events, severe weather, GMD, etc.
  - Human threats - physical/cyber, EMP, etc.

Internally Identified Needs

What's Discretionary?

- Customer or generator connections? NO
- Meeting regulatory or NERC requirements? NO
- Fulfilling relocation & contract commitments? NO
- Addressing safety and other public risks? NO
- Improving local reliability performance? NO
- Modernizing obsolete or degraded facilities ? NO
- Proactive programs for system/asset awareness? NO
  - Must support decisions in vastly more complex operations
  - Optimize maintenance & prioritize replacement of assets
  - Strategic, organized mitigation vs. chaotic, unplanned reaction
- Improve resilience/mitigate natural & human threats? NO
  - Customer experience and public expectations demand it
  - Prioritized resiliency framework to address impacts/risks

AEP Approach

- **Integrate needs into multi-value planned projects**
- **These are *fundamental* to a TO's obligation to serve**

Needs Assessment – Asset Renewal

Customer Inputs

- Collect Customer & Stakeholder Feedback
  - Wholesale customers
  - National accounts & other retail customers

Performance Analysis

- Review Reliability & Availability Metrics
  - System : TSAIFI,TSAIFI-S, TMAIFI, TSAIDI
  - Customer: SAIFI, SAIDI, CAIDI, CMI
  - Evaluate asset contributions to metrics
- Review Trends & Analyze Root Causes
  - Initiating causes; sustained v. momentary causes
  - Maintenance & remediation requirements & trends

Condition Evaluation

- Assess Asset Condition (Per Internal Standards)
  - Physical characteristics: age, design, materials, etc.
  - Site inspection and test analytics
  - Monitoring data (substation Asset Health Center)

Risk Assessment

- Evaluate risk
  - Combine weighted performance & condition scores
  - Review anticipated customer/system/public impact

Prioritize Renewal Portfolio

Develop Mitigating Solutions

Integrate
- Develop cost effective, holistic solutions; combine projects in area
- Review with regional execution teams for coordination & alignment

Scope
- Build upon anchor projects for efficient execution
- Establish targeted, specific programs for standalone asset renewal
- Define & vet specific project scopes, schedules and estimates

Execute
- Authorize improvement plans
- Execute project portfolio
- Submit model changes to RTO (if topology changes)

Note: Many TO-identified projects do not alter topology: e.g., SCADA, RTU, PMU, Telecom, physical/cyber security, protection & control, monitoring, like kind asset replacement, etc.

TO Driven Projects

Examples

Condition Assessment

Physical Characteristics

- Common characteristics
  - Age of asset
  - Age or obsolescence of subcomponents
  - Material content/specs
  - Design features (at manufacture)
    - AEP specs, Industry standards
    - Known defects or obsolescence
    - Insulation coordination, phase clearances
- Asset specific characteristics
  - T-Line specific characteristics
    - Ground Resistance
    - Structure type, height, etc.
    - Shielding features, etc.
  - Substation specific characteristics
    - Bus configuration & switching
    - Structures, control house, flood levels
    - SCADA need criticality

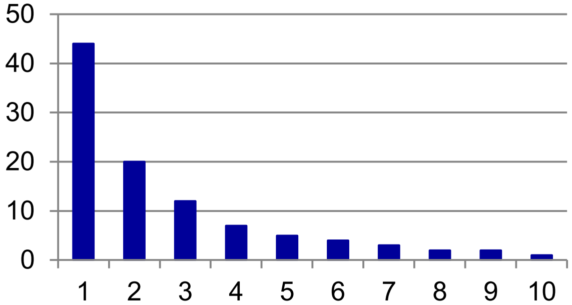
Condition Assessment

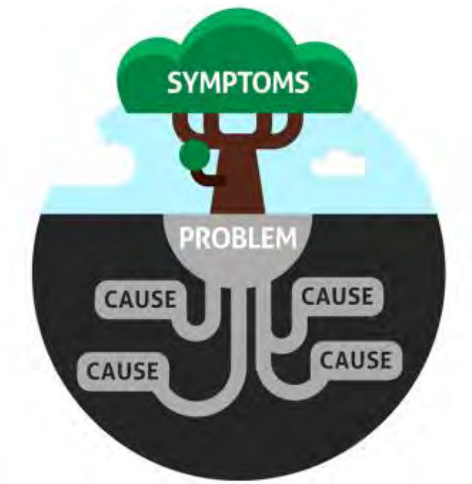
- General
  - Visual inspection results
  - Test results
  - Abnormal conditions (operational impact)
- Line-specific
  - Open conditions reported
    - Number High Risk Conditions
    - Number Medium Risk Conditions
    - Number Low Risk Conditions
- Substation-specific
  - Asset Health Data (includes risk analysis)
    - Transformers
    - Circuit Breakers
    - Batteries
  - Relay obsolescence & mis-operation risk
  - Historical performance (excl. XFMR, CB)
  - Balance of plant condition

Apply Weighted Scoring to Features & Conditions

Performance Metrics & Root Cause

IMPACT ON SYSTEM METRIC (Example)





- **Performance: Calculate 3-yr Transmission Metrics**
  - **System** Metrics: T-SAIDI, T-SAIFI, T-MAIFI, T-SAIFI-Sustained
  - **Customer** Metrics: IEEE SAIDI, SAIFI, CAIDI
  - Assemble historical **System Load Peaks**
  - Identify **System Level** customers served

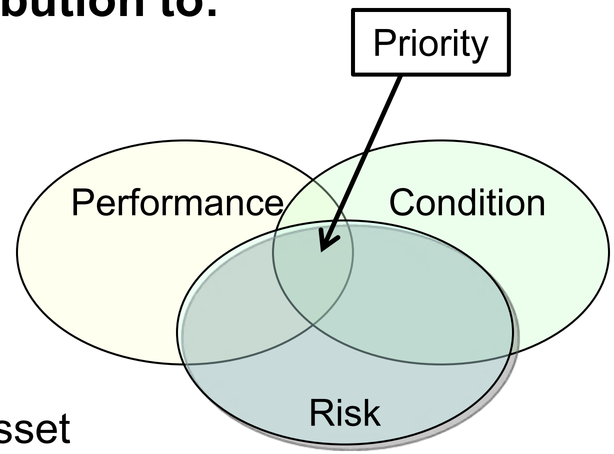
- **Outage Root Cause Review**
  - Review all outages to determine root cause

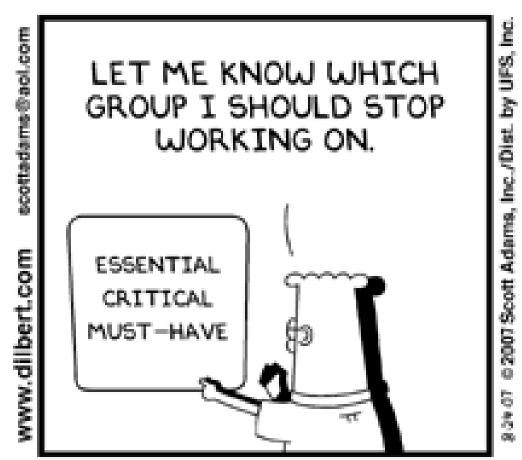
- **Score and Prioritize**
  - Tally outage durations and frequencies
  - Score assets for frequency & duration
    - Applied specifically to lines
    - Applied indirectly (by class) for substation
    - Based on its corresponding cause code
    - 2X weighting for outage frequency > 50%
    - 1X weighting got outage duration >50%
  - Apply threshold score for all lines
  - Filter and prioritize needs

Prioritization Process

Prioritization Process – Rank Each Asset's Contribution to:

- **System Performance** Metrics
- **Customer Impact** Metrics
- **Load Served** v. historical system peak load
- **Number of Customers** served v. total customers
- Assign weighting factors and sum all scores for each asset
- Prioritize assets (e.g., among lines) from highest to lowest

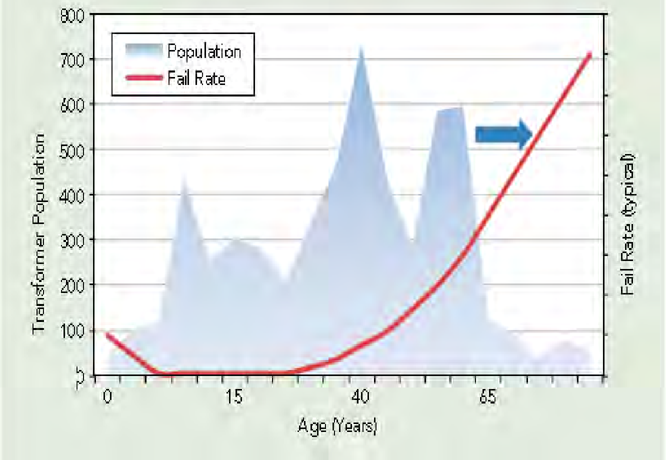




Asset Health Center (AHC) - Overview

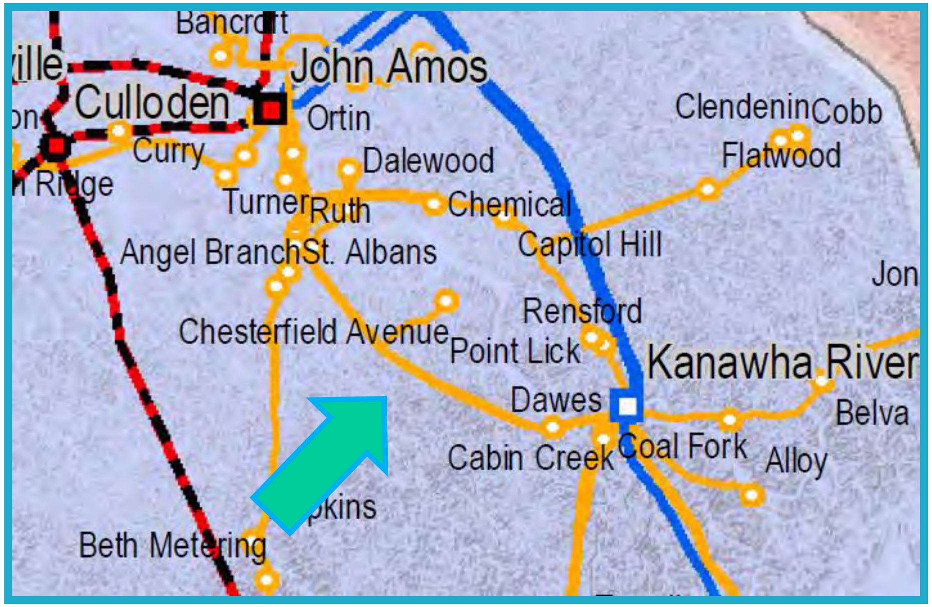
- **Purpose of the Asset Health Center (AHC)**
  - Prevent failures (substation focused to date)
  - Optimize maintenance effectiveness
  - Support asset renewal prioritization
- AEP's aging assets need increasing attention
  - **33% of transformers > 50yrs; 18% > 60yrs old**
  - **33% of T-Line > 70yrs; 49% > 50yrs, 72% > 40 yrs old**
  - Aging assets drive increasing outages, cost
- AHC: Timely & Transformational technology
  - Automates condition analysis to support action plans
  - Determine health index, remaining life, prioritize risk
- Implementation
  - Identified major substation asset condition baseline
  - Completed platform 12/2015
  - Includes transformers, breakers, select batteries
  - Monitors standard on new EHV equipment
  - Retrofit monitors being rolled out in stages
  - Evaluates & documents replacement need priority

Transformer Risk



Multi-Dimensional Solutions

- ❑ Amos – Kanawha River 138 kV line
- ❑ 42-mile corridor, built in 1928
- ❑ 85 yrs service, significant load growth
- ❑ Identified as constraint when Kanawha River generation retired in 2012
- ❑ What is the most cost-effective solution?

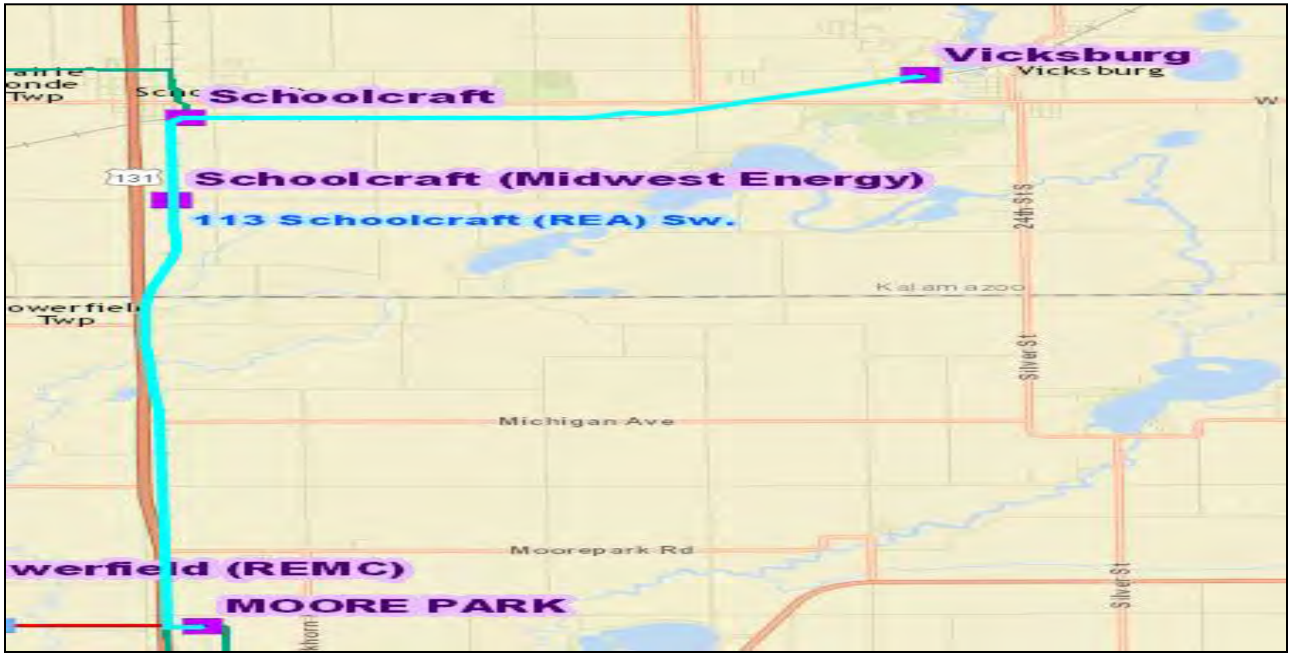


- ❑ *One-dimensional mitigations may include a new parallel 138 kV line requiring fewer outages, and simpler construction or the introduction of a new 345 kV source near Kanawha River*
- ❑ *Multi-dimensional mitigation seeks the most cost effective solution to not only address the identified probabilistic transmission constraint, but also the realistic condition of the asset*
- ❑ *AEP proposed to rebuild the line based on its prioritization methodology*

Moorepark – Schoolcraft 69kV

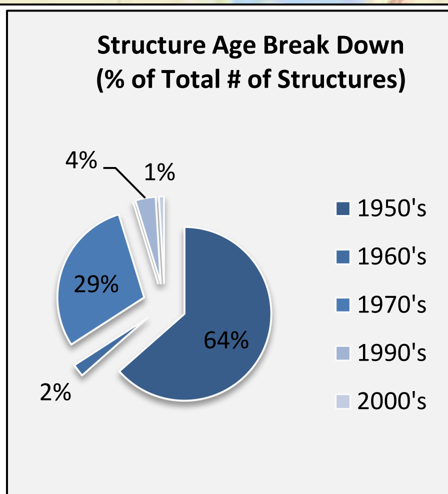
Ranking Value: 19.95 (#1)
3 Yr-SAIDI: 26.75

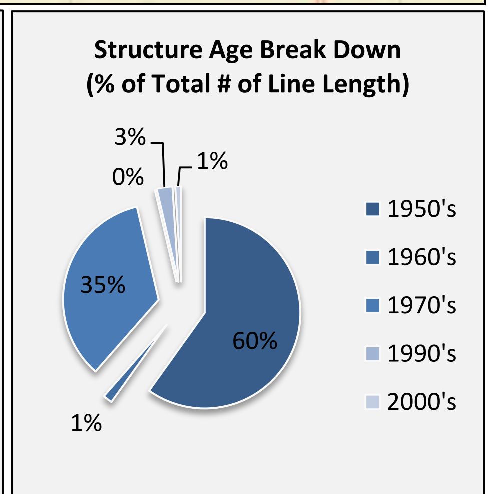
TOR ID	Circuit	Voltage	Length	OPCO	State	Shielding Length	Shielding (%)	Ground Resistance	Structure Height
1802	Moorepark - Schoolcraft	69000	13.11	IMCO	Michigan	13.04	99.617%	No Data	61.7



Severity	Component	Condition	Condition Count
A2	Crossarm	Split	1
A2	Ground Lead Wire	Broken	2
A2	Ground Lead Wire	Stolen	1
A2	Insulator	Broken	1
A2	Insulator	Burnt	4
A2	Insulator - HP	Broken	1
A2	Insulator - HP	Burnt	4
A2	Knee / Vee Brace	Insect Damage	2
A2	Pole	Burnt	1
A2	Pole	Leaning Transverse	1
A3	Ground Lead Wire	Broken	3
A3	Ground Lead Wire	Stolen	2
A3	Guy Wire	Broken	1
A3	Insulator	Broken	1
A3	Insulator	Chipped	1
A3	Insulator - HP	Broken	2
A3	Insulator - HP	Burnt	1

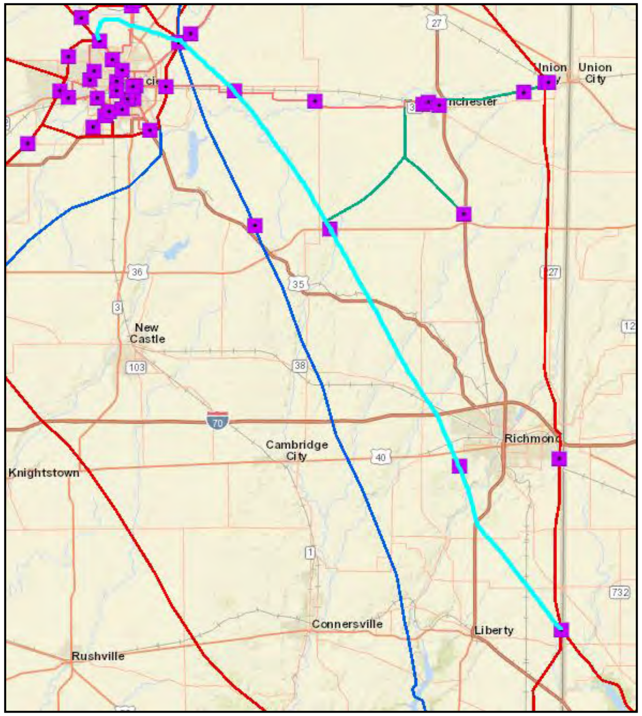
Length	Year	Str Count	Material
0.13	2009	2	Wood
0.15	1997	5	Wood
0.18	1990	2	Wood
0.21	1969	5	Wood
0.44	1956	6	Wood
1.42	1951	26	Wood
4.57	1972	62	Wood
5.99	1951	102	Wood
0.02	1995	1	Wood





College Corner – Delaware 138kV

Ranking Value: 9.93 (#17)
3 Yr-SAIDI: 0.0



Length	Year	Str Count	Material
0.01	1970	1	Lattice
0.05	1952	1	Lattice
0.09	1941	1	Steel
0.11	1941	1	Steel
0.12	1941	1	Wood
0.20	1973	1	Lattice
0.65	1941	4	Lattice
54.31	1941	307	Lattice

Severity	Component	Condition	Condition Count
A1	Conductor	Broken Strands	1
A1	Conductor	Damaged	1
A1	Shield Wire	Broken Strands	1
A2	Body	Vines	1
A2	Conductor	Broken Strands	2
A2	Conductor	Failed	8
A2	Conductor Hdw	Broken	52
A2	Conductor Hdw	Broken Strands	1
A2	Conductor Hdw	Loose	12
A2	Conductor Hdw	Missing Bolt	19
A2	Conductor Hdw	Missing Cotter Key	8
A2	Conductor Hdw	Rust Heavy	2
A2	Conductor Hdw	Worn	4
A2	Crossing Marker	Missing	5
A2	Insulator	Broken	1
A2	Insulator	Burnt	5
A2	Insulator	Chipped	1
A2	Insulator	Loose	1
A2	Insulator	Rust Heavy	10
A2	Insulator Assembly Hdw	Rust Heavy	5
A2	Insulator Assembly Hdw	Worn	2
A2	Knee / Vee Brace	Broken	1
A2	Leg	Vines	21
A2	Shield Wire Hdw	Loose	4
A3	Conductor Hdw	Broken	1
A3	Shield Wire Hdw	Broken	5
A3	Shield Wire Hdw	Loose	3

Length	STANDARD	Structure Count
0.45		4
48.16	8-A	268
2.14	8-B	12
3.46	8-C	21
0.87	8-D	8
0.09	R6S1	1
0.02	Switch	3
0.20	T3E1	1

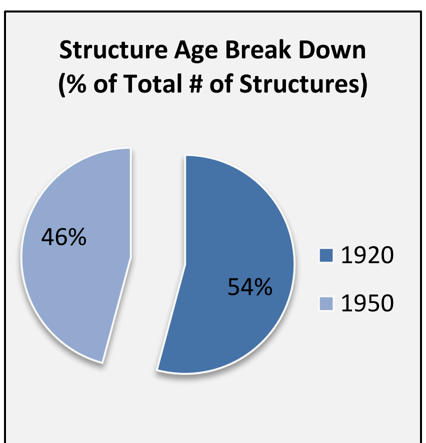
TOR ID	Circuit	Voltage	Length	OPCO	State	Shielding Length	Shielding (%)	Ground Resistance	Structure Height
604	College Corner - Delaware	138000	56.27	IMCO	Indiana	56.35	99.858%	No Data	55

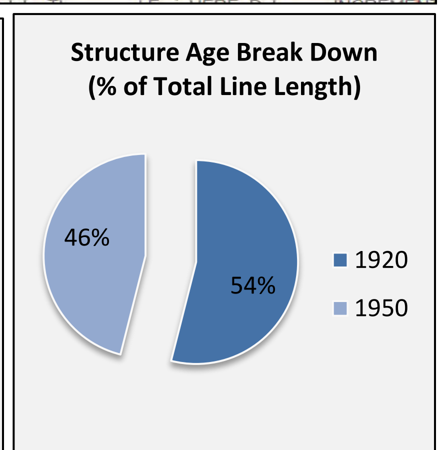
East Lima – (Ford) - Rockhill 138kV

Ranking Value: 0.0
3 Yr-SAIDI: 0.0

TOR ID	Circuit	Voltage	Length	OPCO	State	Shielding Length	Shielding (%)	Ground Resistance	Structure Height
699	East Lima - Rockhill	138000	4.80	OPCO	OH	4.80	100%	No Data	61.4

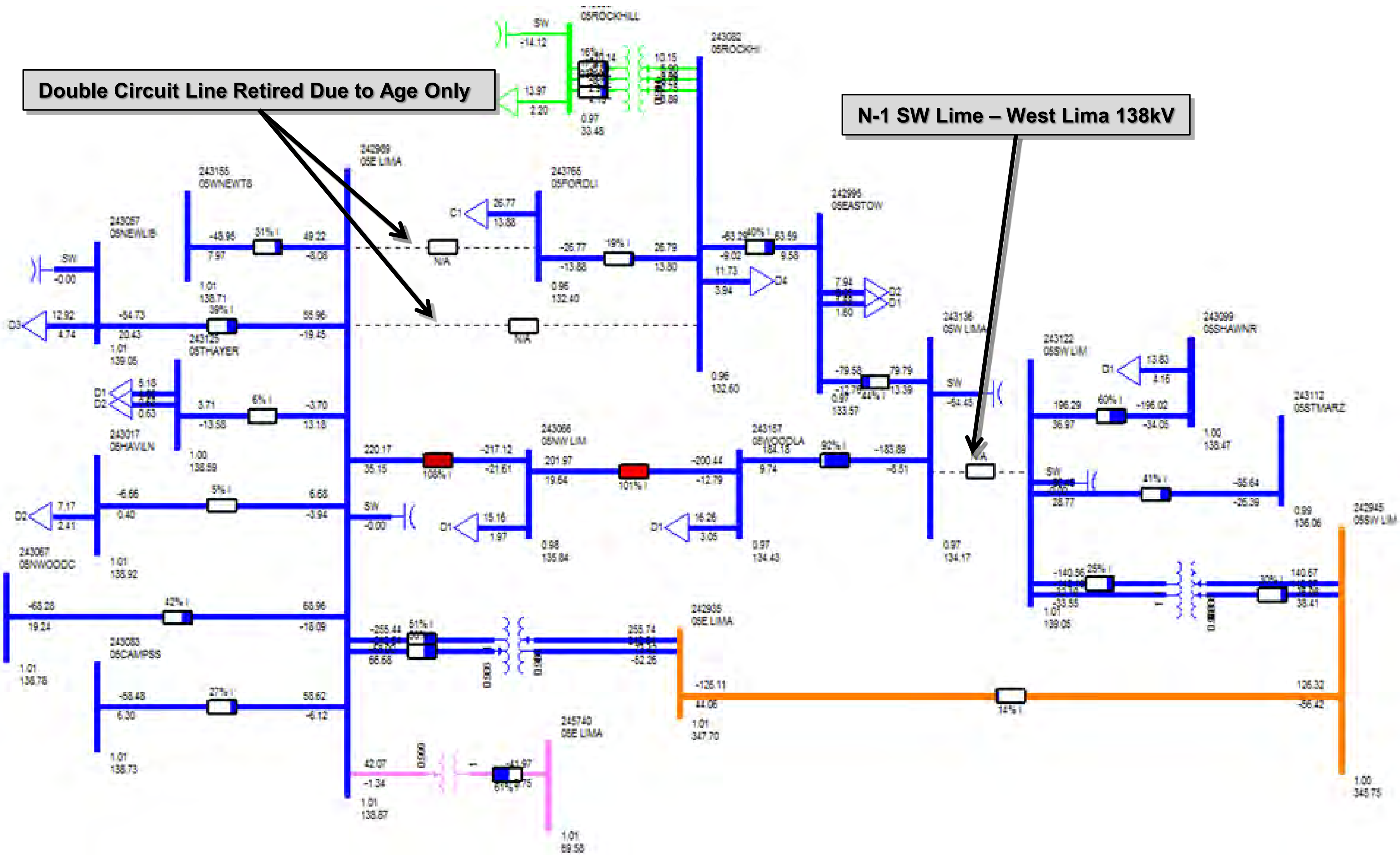
Length	Year	Str Count	Material
0.16	1925	1	Lattice
0.23	1956	1	Lattice
2.43	1924	12	Lattice
1.98	1955	10	Lattice





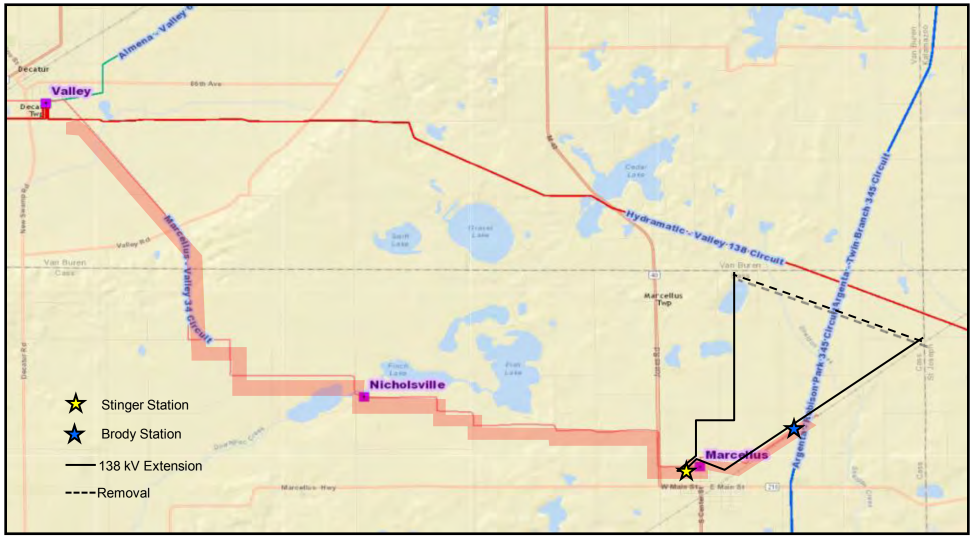
Double Circuit Line

East Lima – Rockhill, East Lima – Ford – Rockhill 138kV
N-1 Loss of SW Lima – West Lima 138kV



Marcellus-Valley 34.5 kV Ckt

- Age and condition
  - Average age ~ 1975
  - ACSR conductor core nearly gone
- SAIDI
  - 4.53 (3-year average)
- Recoverability
  - ~13 MVA load served radially
  - 34.5 kV is not recoverable
- Low Voltages
  - At Nicholsville and Marcellus stations
  - < 0.92 PU under N-1 conditions
  - Loss of Valley 138/69-34.5 kV XFMR



- Proposed Solution Overview
  - Establish new Stinger 138/12 kV station
  - Replace Nicholsville & Marcellus 34.5 stations
  - Establish Brody station to replace Midwest REA's Marcellus 34.5/12 kV station
  - Extend 138 kV line to Brody & Stinger stations