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2019 Asset Renewal Program Preliminary Solutions

Stakeholder and Customer Presentation – May 2, 2019

Scott Adams

Outline

- 2023 Program specifics
- Long term forecast
- Project Needs and Analysis – Arcadian Substation

Asset Renewal Program Objectives

- Safety – public and worker
- Minimize total life cycle cost
- Compliance
- Manage risk
- Reliability performance improvements
- Environmental performance improvements
- Coordination with Stakeholders

Asset Renewal Program Criteria

Condition

O&M Cost savings
Health indexing
Performance and projected deterioration

Obsolescence

Manufacturer and Field technical support
Spare parts availability
Application
Analog phone circuit elimination

Reliability

Industry failure rates
Known design issues
Single element failure and testing exposure
Outage reduction
Poor lightning performance
Relay system misoperations, security, dependability
Human performance issues

Compliance, Safety, Environmental

Ratings methodology (FAC-008)
NESC clearance from grade and other structures
NESC working clearances in control houses
NESC structure strength
Environmental impacts

Asset Renewal Forecast – Sub and T-Line

	2023	2024	2025	2026	2027	2028	Grand Total (\$000's)
Arresters	\$299	\$220	\$138	\$0	\$59	\$0	\$717
Batteries and Chargers	\$1,283	\$2,927	\$1,945	\$2,204	\$1,238	\$2,551	\$12,148
Breakers and Switchers	\$9,816	\$9,762	\$6,695	\$1,470	\$8,309	\$1,470	\$37,523
Capacitor Banks	\$0	\$0	\$860	\$443	\$912	\$1,409	\$3,624
Control Houses	\$2,251	\$6,956	\$11,941	\$4,919	\$0	\$7,829	\$33,895
Instrument Transformers	\$610	\$1,268	\$467	\$487	\$1,818	\$1,466	\$6,117
Physical Security	\$19,733	\$20,844	\$2,860	\$2,089	\$2,715	\$4,817	\$53,059
Power Transformers	\$16,866	\$11,607	\$12,976	\$12,203	\$6,983	\$13,328	\$73,964
Reactors	\$0	\$765	\$263	\$0	\$0	\$431	\$1,458
Relays	\$6,989	\$9,791	\$11,419	\$20,736	\$22,145	\$19,568	\$90,648
SCADA	\$2,503	\$3,111	\$3,028	\$4,383	\$6,212	\$5,198	\$24,436
Switches	\$3,702	\$3,257	\$2,158	\$2,022	\$2,026	\$1,102	\$14,267
Substation Total	\$64,053	\$70,510	\$54,750	\$50,956	\$52,417	\$59,168	\$351,855
Transmission Line	\$91,200	\$59,100	\$119,700	\$93,100	\$54,800	\$200,000	\$617,900
Grand Total	\$155,253	\$129,610	\$174,450	\$144,056	\$107,217	\$259,168	\$969,755

Asset Renewal Conceptual Estimate
 In-Service Dates
 Includes 3% inflation, with year 0 = 2019 (\$000's)



Asset Renewal –10 Year Forecast

Substation Equipment Quantities

Asset Renewal Equipment Quantities Forecast by Asset Type - 2023-2028

Row Labels	2023	2024	2025	2026	2027	2028	Grand Total	Average % per Year
Arresters	54	8	18		9		101	0.21%
Batteries and Chargers	17	28	20	22	12	24	178	2.25%
Breakers and Switchers	44	21	26	5	27	8	200	0.87%
Capacitor Banks			2	1	2	3	25	0.51%
Control Houses	2	2	5	2		3	27	0.93%
Instrument Transformers	22	43	17	18	61	47	474	0.18%
Power Transformers	11	10	9	4	7	8	64	1.80%
Reactors		3	2			3	9	0.30%
Relays	210	105	180	295	284	245	2552	2.86%
SCADA	21	22	16	29	39	29	312	0.88%
Switches	150	65	72	67	70	33	657	1.15%
Grand Total	550	323	369	444	512	404	4643	

T-Line Asset Renewal Projects

Continuing Asset Renewal Condition Need	2019 Projected Need Year	Project Status	Planning Zone	Need Category	MISO MTEP Appendix Status	MTEP PRJiD	MTEP Cost or Cost Range (M\$)
Portage - 9 Mile 69kV lines (6901/ESE_6902) Re-insulate	2023	Provisional	2	Improve condition and increase reliability performance of existing line	B	14909	<10
Chandler-Delta (UPPCO) 69kV line (Delta 1) Partial Rebuild	2023	Provisional	2	Improve condition and increase reliability performance of existing line	B	14909	<10
Conover – Mass 69kV (6530) Partial rebuild	2025	Provisional	2	Improve condition and increase reliability performance of existing line	Target B, MTEP19	16495	<10
9 Mile SW STA – Pine River 69kV (6921/23) Partial Rebuild	2025	Provisional	2	Improve condition and increase reliability performance of existing line	Target B, MTEP19	16496	<10
Rebuild Academy - Columbus 69kV	2023	Provisional	3	Improve condition and increase reliability performance of existing line	B	10590	<10



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Arcadian Substation –
Needs and Alternatives Analysis Detail
Estimated Cost - \$28M
2023 ISD

Arcadian Substation – Overview

- 345/138kV Substation
- Located southwest of Milwaukee
- Serves the regional 345kV network and 138kV network around Milwaukee
- Constructed circa 1960's and 1972
- 5x 345kV OH Lines
- 3x 138kV OH Lines
- 3x 345/138kV transformers
- Local Distribution Co. Assets
- 1x 230kV Loop-Through



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Arcadian Asset Renewals

- **345kV Yard Equipment**
 - 2 LTC Transformers
 - 3 SF₆ Breakers
 - 11 Disconnect Switches
 - 6 Arresters
 - 1 Circuit Switcher
 - 3 CT's
- **138kV Yard Equipment**
 - 2 Oil Breakers
 - 8 Disconnect Switches
 - 6 Arresters
- **Protection and Control**
 - Control Building
 - 26 Relay Panels
 - 2 RTU's
 - 1 Battery, 3 Chargers



Power Transformers

2 1971-vintage Westinghouse Transformers

- Design
 - Tank gasket design is prone to oil leaks and expensive repairs
 - Main winding design is prone to gassing
- Dissolved Gas Analysis
 - Gases in oil are increasing on T3; indicates insulation deterioration within the transformer
- Bushings
 - Type “O”, history of oil leaks in test tap area, gaskets at end of life, power factor increasing on some bushings indicating insulation nearing end of life
 - Bushings are 20+% of transformer failures
- Load Tap Changers
 - Compartment and driveshaft seals developing oil leaks in the past 5 years
 - Regulated tertiary voltage, only two left of this voltage on the ATC system
 - Non-typical installation and no longer needed point of failure
 - LTC’s are high contributors to many transformer failures
- Transformers have been exposed to tertiary through-faults which contributes to failures
- Lack of oil containment for environmental controls



Breakers / Circuit Switcher

- 345kV
 - 2 1982-vintage Allis Chalmers LPO-362 SF6 Breakers
 - Live tank breaker leaves protection gaps in design
 - No longer supported by the manufacturer
 - Parts not available
 - 1 1984-vintage Delle Alsthom FX362-22 Gas Breaker
 - Live tank breaker leaves protection gaps in design
 - No longer supported by the manufacturer
 - Parts not available
 - Craft experience is limited for troubleshooting and maintenance
 - 1 1970-vintage S&C Mark II Circuit Switcher
 - Cannot be used for fault clearing– overduited and inadequate design for clearing a fault.
 - Parts not available
 - Craft experience is limited for troubleshooting and maintenance.
- 138kV
 - 2 1970-vintage Allis Chalmers model BZO oil breakers
 - Hydraulic mechanism is prone to trouble callouts for loss of close energy (failure to operate)
 - Craft experience with the PH-33E-5 hydraulic mechanism is limited for troubleshooting and maintenance
 - Ohio Brass “GK” bushings have been good performers but have power factor results trending higher, indicating insulation deterioration



Line, Bus and Transformer Relay Panels

- 26 panels with relays

- 34 electromechanical relays
 - Obsolete technology and improved protection with the newer relaying technology
 - Do not support fault locating, oscillography, or remote access for troubleshooting and fault analysis
 - Parts are no longer available
 - Originally installed in 1972
- 11 solid state relays
 - Relays will fail without alarming to EMS/SCADA
 - Obsolete technology and improved protection with the newer relaying technology
 - Do not support fault locating, oscillography, or remote access for troubleshooting and fault analysis
 - Parts are no longer available
- 34 microprocessor relays
 - Microprocessor relays have a 25-year life of power supply and internal capacitors.
 - Obsolete technology and improved protection with the newer relaying technology



Protection and Control Building

- Inadequate design for severe weather and physical security
- Control cabling to the yard are at end of life
- Close proximity of existing building to power transformer and need for oil containment
- Inadequate and poor performing HVAC and insulation systems
- Inadequate and poor performing AC building wiring systems
- Construction cost efficiencies when replacing relays at the same time



Disconnect Switches

- 345kV
 - 5 Schwager Wood TA-3A Switches
 - Parts are not available
 - 1 Westinghouse V-2 Switch
 - Develop hot spots
 - 1 ITE TTR-6 Switch
 - Develop hot spots
 - Become difficult to operate inoperable near end of life
- 138kV
 - 5 Allis Chalmers ATA-2A Switches
 - Parts are not available
 - 1 Siemens AVB Switch
 - Parts are not available



Instrument Transformers

- 3 1983-Vintage Trench OSKF-1300 Current Transformers
 - This particular vintage has a high failure rate (factory manufacturing start up issues)
 - Prone to moisture ingress and failure to operate relays properly
 - Design is inadequate and has a gap in protection



Arresters and Insulation Systems

- **345kV and 138kV**
 - 6 Ohio Brass MPR transformer arresters
 - Silicon Carbide arresters do not protect equipment effectively
 - Moisture seals are at end of life. Arrester failure can be catastrophic and take out other elements (bushings, etc.)
 - Industry replacement on average is 40 years; these arresters are beyond that timeframe
 - Bus Insulation is under evaluation. Typically expect the system to perform reliability for 50 years.



Thoughts and feedback??

For more information, please contact
Scott Adams
Phone: 906-779-7930
Email: sadams@atcllc.com

