Asset Management Program Summary 2019

Western Area Power Administration

LETTER FROM THE CHIEF OPERATING OFFICER

Western Area Power Administration launched its formal Asset Management program in 2015. AM incorporated a new approach of quantifiably scoring asset health and risk into the successful asset maintenance documentation process already in use. The desired result was to understand more about the organization's transmission and substation assets and to support grid reliability and resilience with capital planning and maintenance decisions informed by data. As AM moves into its fifth year, its accomplishments and value to WAPA are growing.

In 2019, the program updated its communication strategy to increase stakeholder outreach and made its data more accessible to a broader group of WAPA stakeholders. Functional areas that could potentially find new uses for AM reports and analyses include Power Marketing, Operations, Transmission Business Unit, Construction and Engineering. Sharing valuable asset health, risk and maintenance analyses and well-documented processes with stakeholders will continue to be a primary focus of the program.

Systematic approach

WAPA's field crews have always documented their valuable knowledge as part of routine maintenance operations. Standardizing these documentation efforts as part of a formal AM program increases opportunity to integrate this information across WAPA's business functions. AM uses a two-pronged strategy for maximizing data collection to protect assets:

- Asset Planning collects and analyzes performance and lifecycle data to determine the health of critical equipment and associated risk to the power system. This information supports planning for capital expenses and prioritizing power system maintenance, repairs or replacements.
- Asset Maintenance uses the data from field crews that categorize and describe maintenance activities to inform health index determinations, understand equipment performance and drive improvements to WAPA's reliability-centered maintenance program. This data is typically generated from planned and unplanned maintenance activities.

Since 2018, AM has been collaborating with fellow member utilities of the North American Transmission Forum on a project to improve the quality of field-generated data related to in-service equipment problems. The resulting data collection methodology uses a standard set of terms, or codes, to describe problems observed in the field. When collected industrywide, this data will enable more efficient analyses of the causes of equipment malfunctions and failures. WAPA contributed to the effort, providing insight based on crews' past experiences with problem coding. AM expects to see improvement in existing processes when the new methodology is implemented in 2020. This project is an important example of WAPA's leadership in the emerging field of asset management.

More assets to analyze

Four new asset classes were added in 2019: current transformers, coupling capacitor voltage transformers, station batteries and network equipment. In 2020, AM will begin adding more asset classes:

- Power circuit breakers, 100 kilovolts and below.
- Transformer bushings.
- Load tap changers.
- Mobile cranes.

These additions are expected to be a multiyear effort and will include an inventory refresh, use study and management methods analysis.

AM actively tracks and monitors more than half of WAPA's approximately $4.3 billion in transmission assets, and the addition of asset classes will incrementally increase the number of assets in the program each year.

When WAPA launched the AM program, the first assets to be addressed were the ones with the highest value, highest consequence of failure and longest acquisition lead times. AM will continue to strategically add WAPA's remaining assets based on more granular criteria determined to provide the most benefit to the organization.

Looking ahead

Going forward, AM will continue to focus on data accuracy, validating processes with subject matter experts and monthly strategic data cleanups. Expanded uses for asset analyses, such as prioritizing physical security upgrades and vegetation management projects, is another area AM will continue to explore in an effort to add value for stakeholders.

Asset Management analyses and reports have already proven to be valuable and strategic tools for both WAPA and its customers, and we are excited about the continued role the program plays in today's data-driven environment.

Kevin Howard, COO

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ABOUT ASSET MANAGEMENT

WAPA owns, operates and maintains more than 17,000 circuit miles of transmission lines and approximately 324 substations. These assets, located in widely diverse operating conditions, pose unique, fleetwide asset management challenges. Asset Management meets these challenges with a methodology that can be consistently applied to assets throughout WAPA's 15-state footprint, four distinct regions and one management center.

By identifying risk associated with WAPA's critical systems and equipment and providing data-driven insight on mitigating that risk, AM supports a wide range of efforts that reinforces the resilience and reliability of the grid. The approach combines extensive field knowledge with input from applicable WAPA departments to enhance existing databases, perform analyses and generate reports that inform objective decisions on budget development, capital plans, operations and maintenance practices, financial forecasting and safety and security upgrades.

Objectives

- Integrate all assets into risk-based methodologies to strategically inform capital investments.
- Maximize value of assets.
- Correlate asset maintenance history, health indices and consequence values to drive risk-based decisions.
- Use asset population and performance data to inform best maintenance practices.

Near-term goals:

- Strategically add asset classes to the AM portfolio to support regional capital investment needs.
- Communicate asset management data analyses to stakeholders.
- Create more intuitive and informational displays to share asset management reports.
- Leverage historical work order data trends to optimize asset maintenance tasks and schedules.
- Leverage consequence data to inform additional business decisions beyond existing AM stakeholder base.

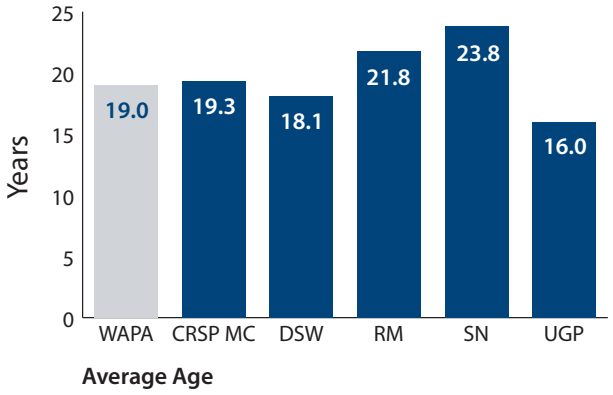
Long-term goals:

- Integrate asset health indices and risk scores to drive condition-based and predictive maintenance activities.
- Streamline electronic collection of asset and maintenance data from field crews and operational systems.
- Integrate artificial intelligence into data gathering, validation and analysis.
- Implement full lifecycle management of assets.

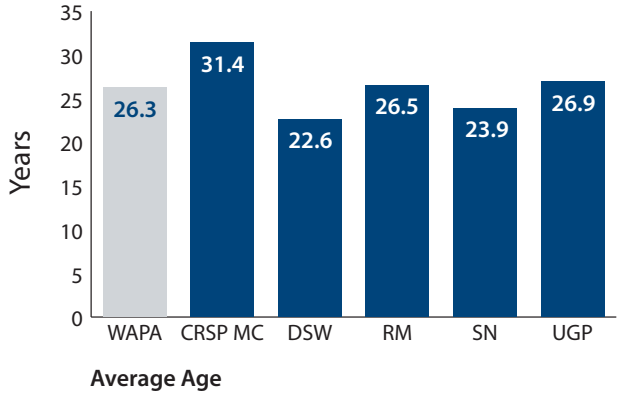
WAPA ASSETS AT A GLANCE

AVERAGE AGE OF ASSETS

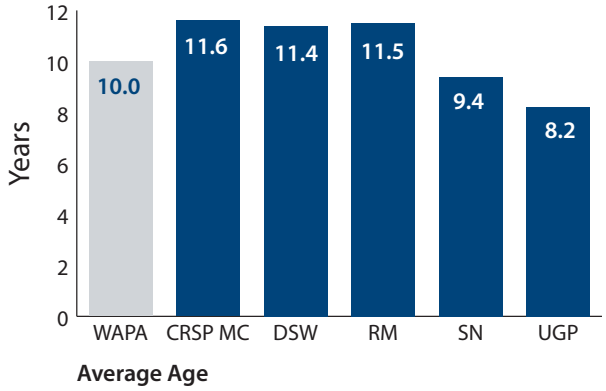
Circuit Breakers



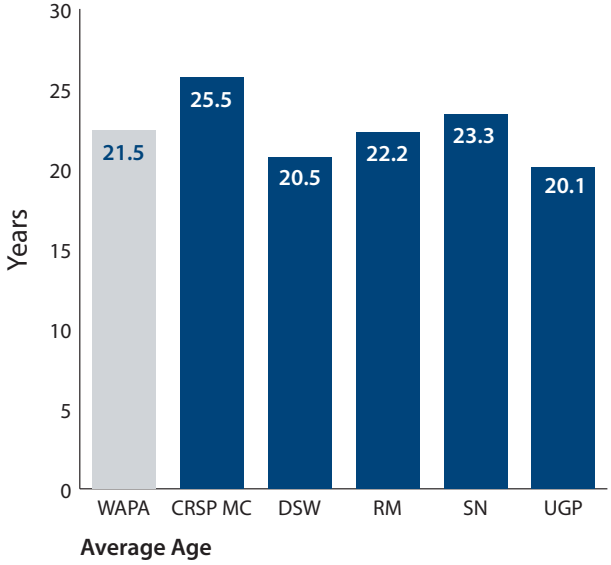
Transformers



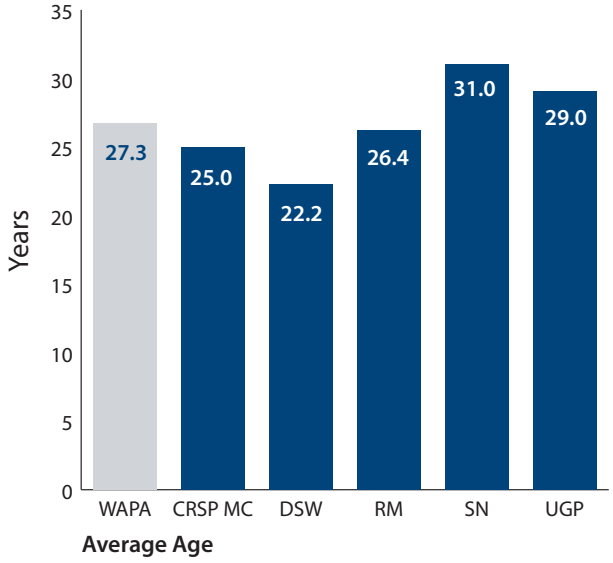
Batteries



Coupling Capacitor Voltage Transformers



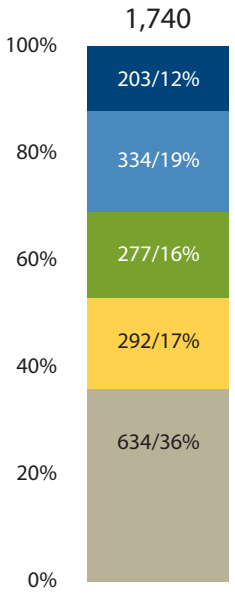
Current Transformers



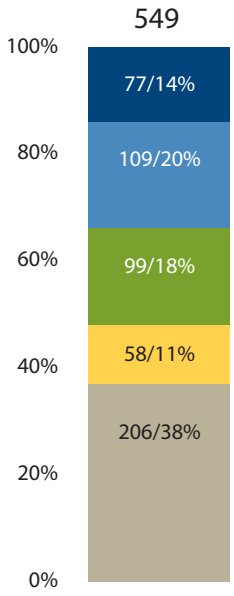
Commentary: CTs, CCVTs and station batteries have different risk and health scores than other assets due to typically short lead times for replacement and the current lack of individual asset health tests.

ASSETS BY REGION

Circuit Breakers

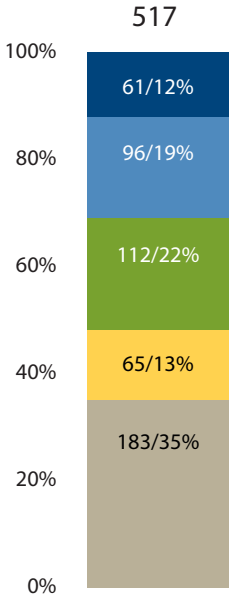


Transformers

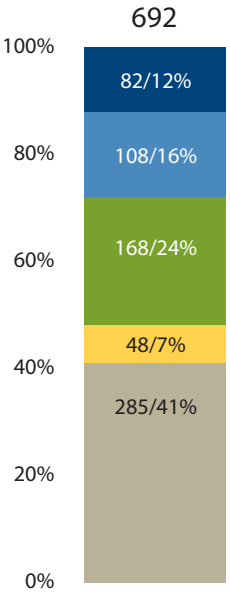


Commentary: Single-phase assets are counted as stand-alone when part of a three-phase transformer bank.

Transmission Line Systems

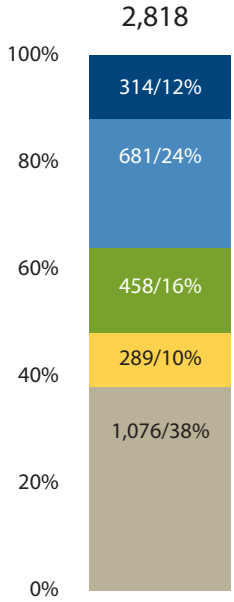


Batteries

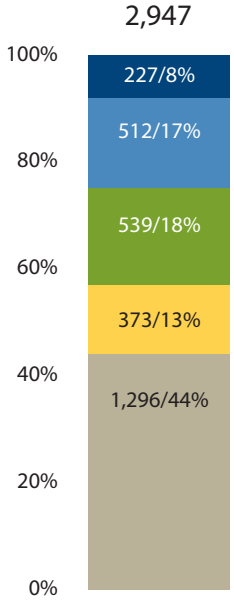


Commentary: WAPA Headquarters has one battery.

Coupling Capacitor Voltage Transformers



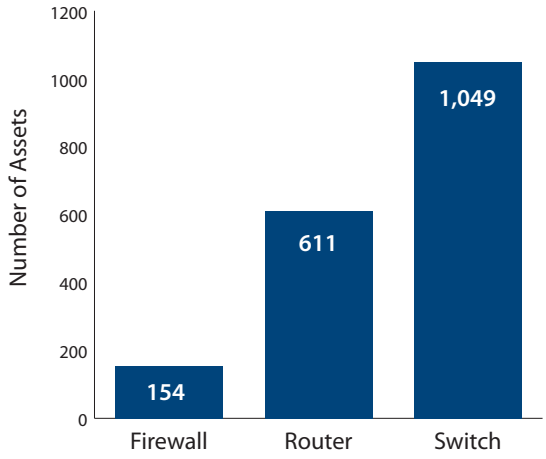
Current Transformers



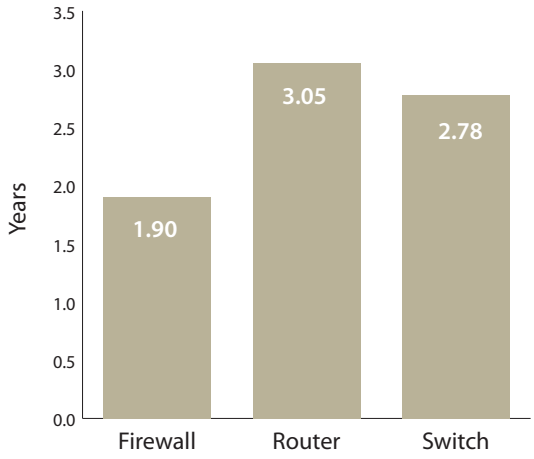
CRSP MC DSW RM SN UGP

NETWORK EQUIPMENT

Equipment by Type



Average Remaining Service Life



Commentary: Information technology equipment is considered a WAPA-wide asset. For this asset class, data regarding the expected end-of-service life is most useful for determining asset health.

Process improvement personnel review procedures with electricians for a 345-kV circuit breaker at Glen Canyon Substation.

ASSET CONDITION DATA

Asset Management collects data based on the equipment's criticality to WAPA, lead time for acquisition and replacement, its relevance to the asset class and the ability to validate the accuracy of the data. Because of the diverse nature of WAPA equipment and systems, AM may collect different types of data and apply different metrics to determine health and risk for specific assets or classes.

Some asset classes have health and risk scores while others do not based on the ability to gather relevant data and the criticality of that asset to the power system. A risk score would not be calculated—or needed—for an asset with minimal lead time for acquisition or minimal installation time. The health-based criteria that drive a health score might not be readily available during routine maintenance activities or the consequence of an asset failing might not be substantial enough to warrant a risk score.

For example, there are no health tests for current transformers and coupling capacitor voltage transformers, and WAPA generally has spares on hand or can acquire more with minimal lead time. Basing their replacement on age measured from installation date makes sense in this case. Transmission-line segments, however, are more complex and made up of multiple components and different materials, all exposed to the local elements. Also, their failure carries serious consequences for WAPA's system. Collecting more detailed data on these assets—such as condition of individual line components—creates a clearer picture of their condition and potential for failure.

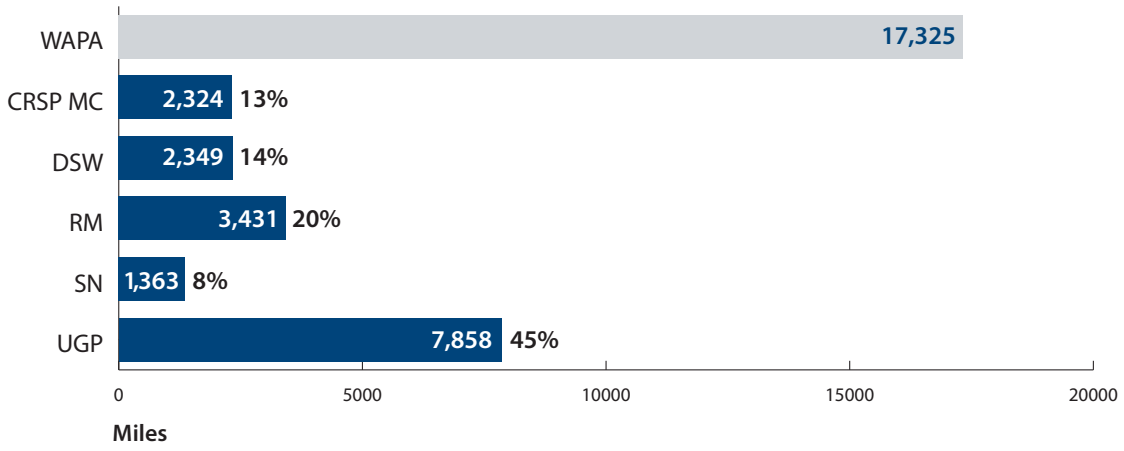
A construction crew installs new air core reactors at Ault Substation.

TRANSMISSION LINES

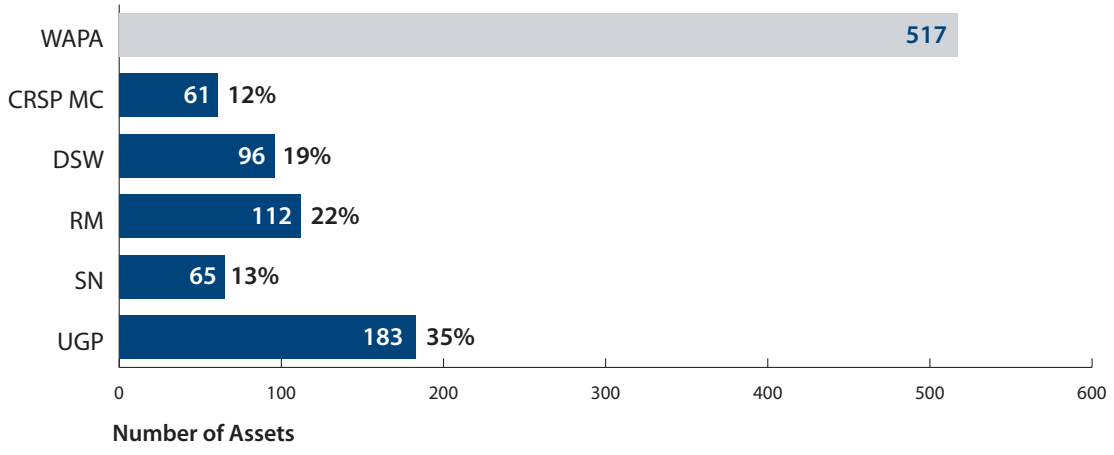
Asset Management is moving away from age-based assessments by formally introducing a condition-based health index for transmission lines equal to or greater than 100 kilovolts. Through routine inspection, performance ratings are assigned to individual structures and components. These ratings drive health-index algorithms by integrating field knowledge into the overall condition rating of WAPA's transmission line system. Risk and health index for transmission lines will be reported in 2020.

TRANSMISSION LINE ASSETS OVERVIEW

Transmission Line Miles by Region

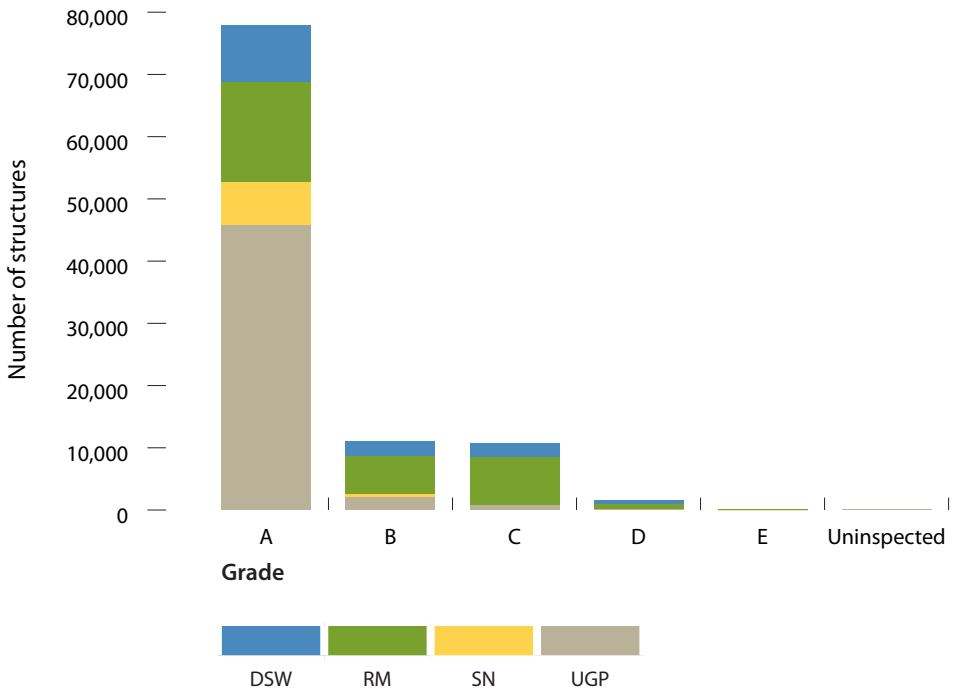


Transmission Line Systems by Region



TRANSMISSION LINE INSPECTION DATA

Transmission Line Structure Maintenance Priority Rating



Commentary: Maintenance priority ratings were developed by the Electric Power Research Institute to assign a standardized condition to each transmission line structure or conductor component based on periodic visual inspections, physical test results and age. These ratings, which range from "A" (like new) to "E" (imminent failure), are applied to every component visual inspection.

Definition of each rating is:

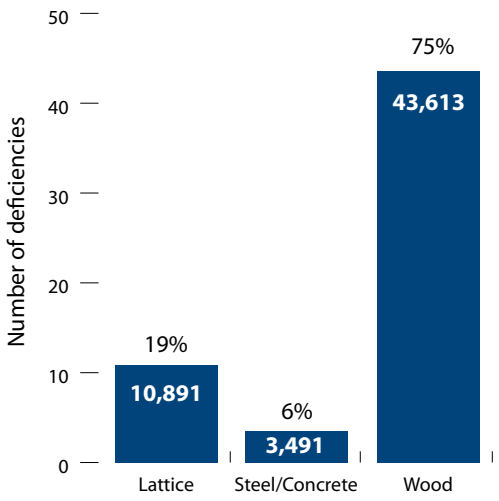
A - Good condition, no action required.
B - Minimal defect, monitor degradation.
C - Moderate defect, schedule maintenance.
D - Severe defect, repair as soon as possible.
E - Component failed, repair immediately.

Transmission lines within the boundaries of the Colorado River Storage Project Management Center territory are maintained by Rocky Mountain and Desert Southwest regions.

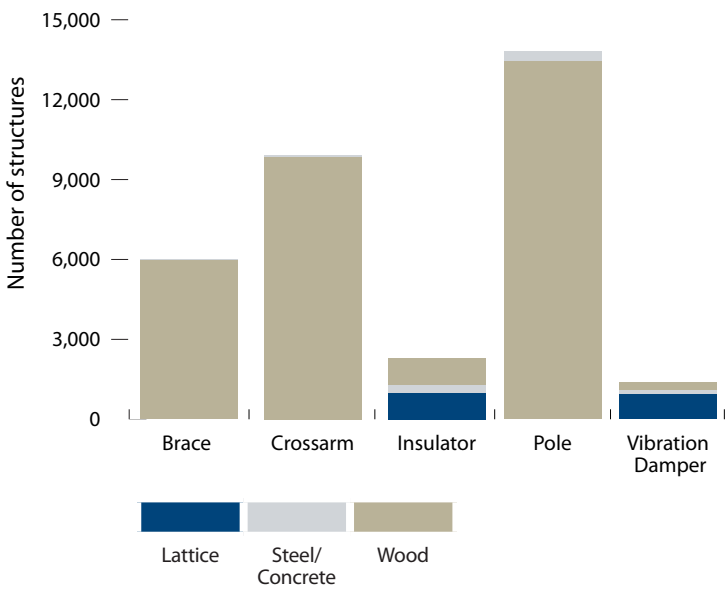
A field crew reviews reliability-centered maintenance inspection points on a 345/230-kV transformer.

TRANSMISSION LINE INSPECTION DATA

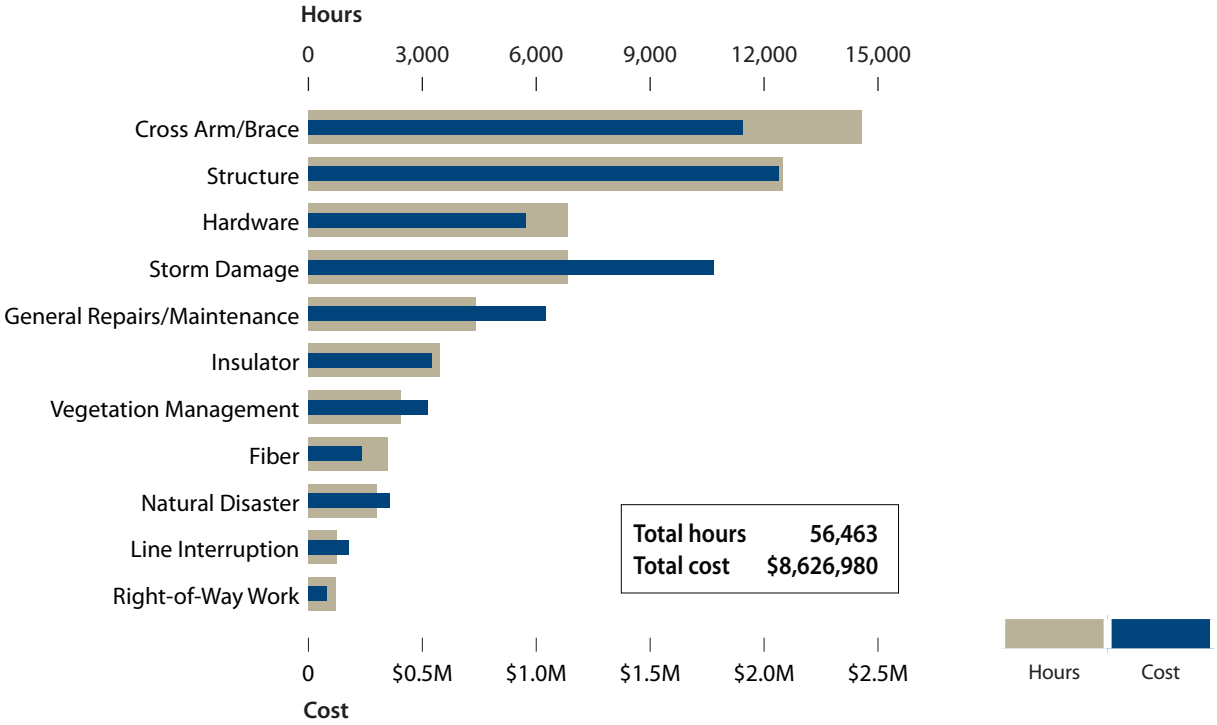
Transmission Line Structure Deficiencies by Material



Transmission Line Structure Deficiencies by Component



Transmission Line Maintenance Items by Cause



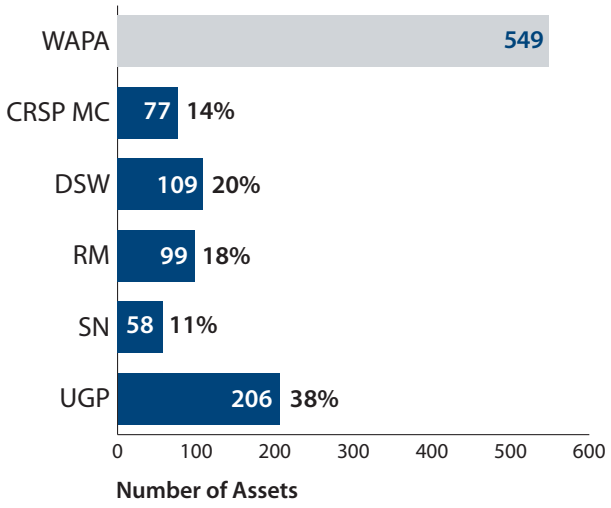
Commentary: The data is for reactive, corrective and emergency maintenance work combined for all types of transmission-line structures. It does not include preventive maintenance.

TRANSFORMERS

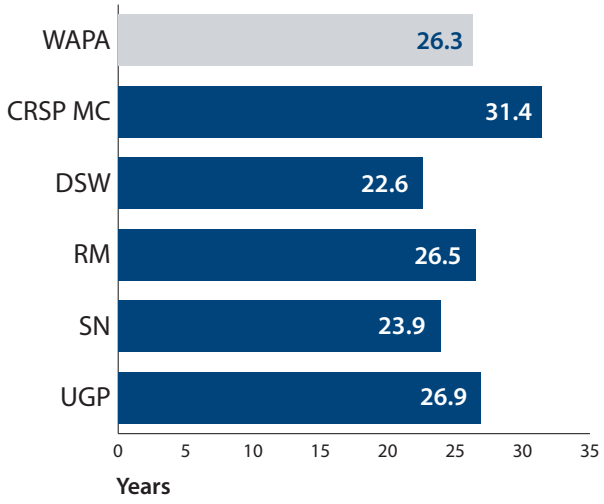
The transformer asset class includes power transformers, grounding transformers, oil-filled reactors and phase-shifting transformers. AM typically counts single-phase assets as stand-alone when part of a three-phase transformer bank.

TRANSFORMER ASSETS OVERVIEW

Transformer Count by Region



Average Age of Transformers

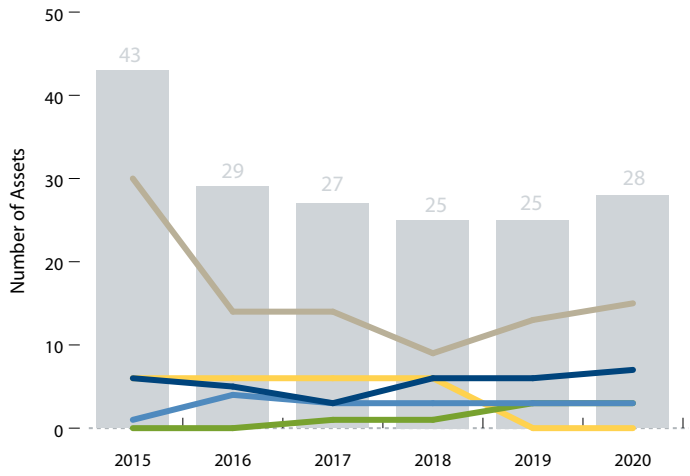


Maintenance technicians install a new bushing in a 345/230-kV transformer at Mead Substation.

TRANSFORMER ASSETS: RISK AND HEALTH INDEX OVERVIEW

Trend: Exceeds Risk

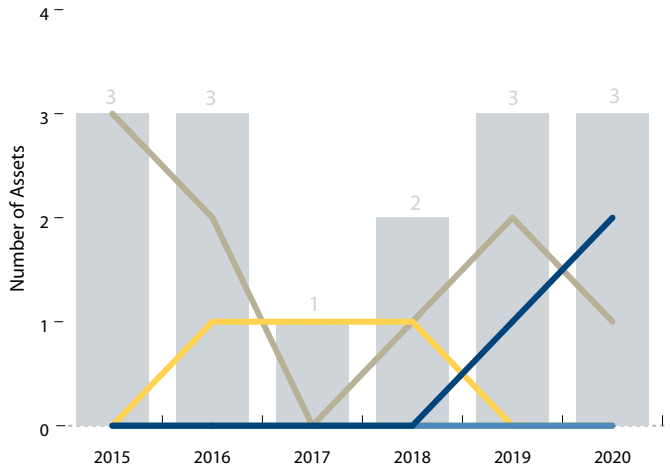
Threshold > 2



Commentary: Transformer risk is quantified by understanding the consequence of asset failure within the transmission system and correlating that to individual health scores.

Trend: Below Health Index

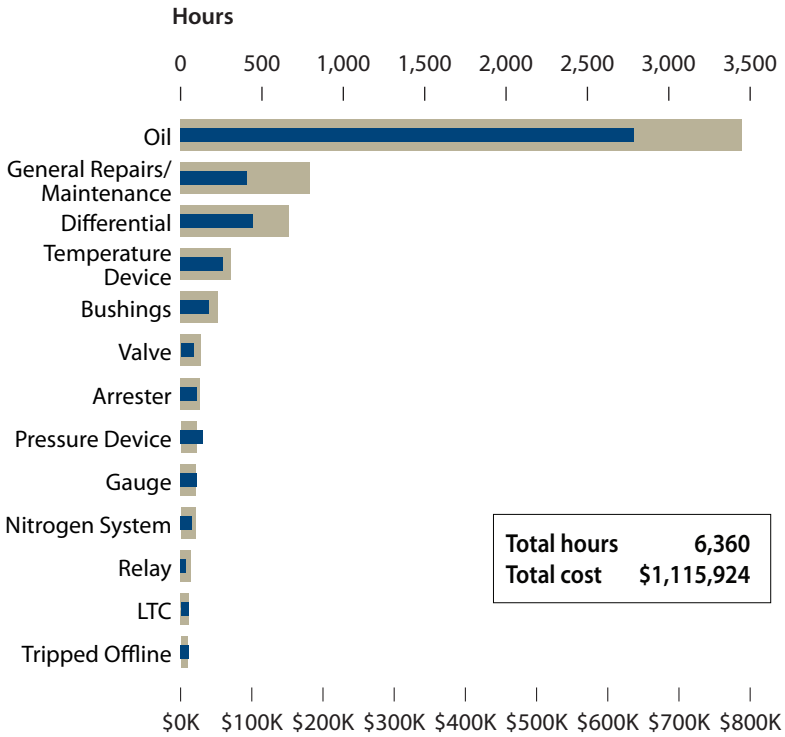
Threshold < 50



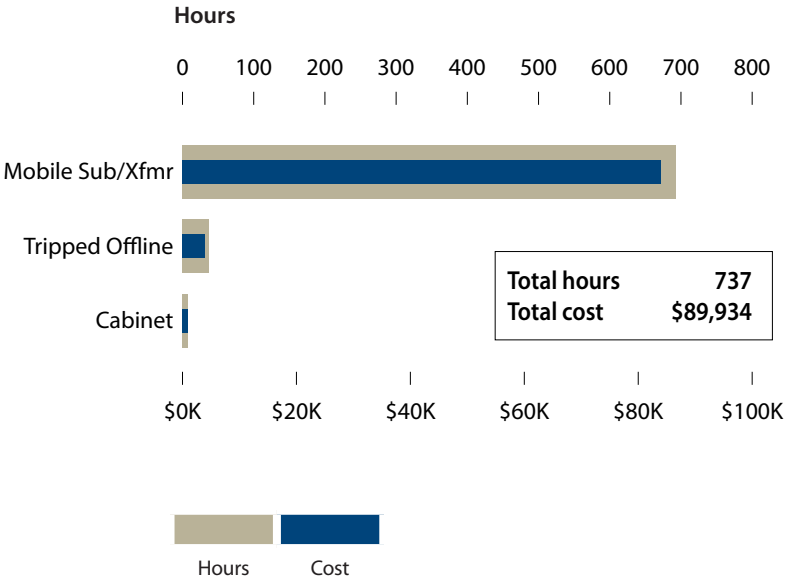
Commentary: The health of oil-filled transformer-type assets is determined by field information gathered on oil condition, operations and maintenance history, electrical condition and age or design factors.

TRANSFORMER MAINTENANCE ITEMS

Power Transformers

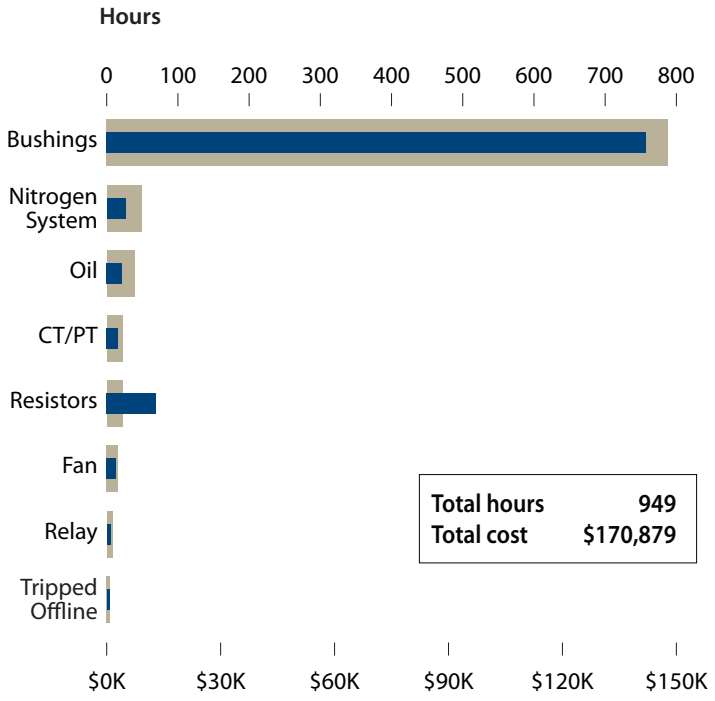


Mobile Transformers

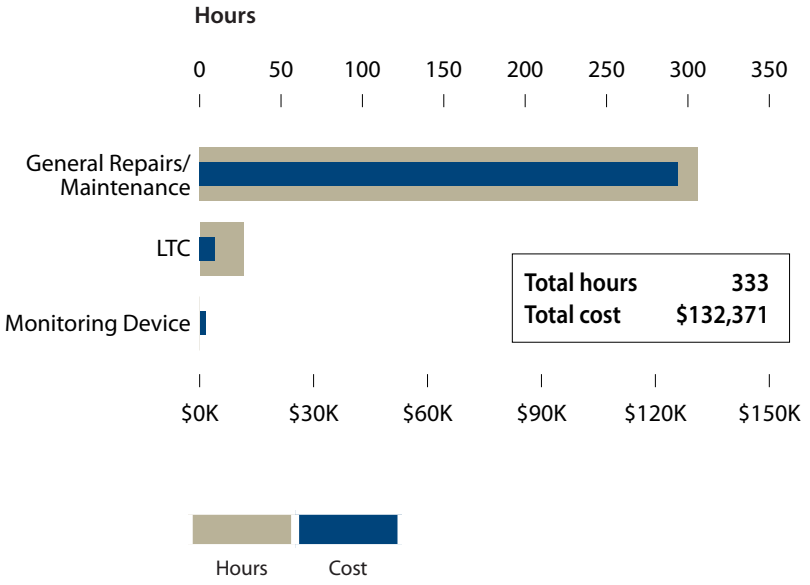


TRANSFORMER MAINTENANCE ITEMS

Oil-Filled Reactors



Phase-Shifting Transformers



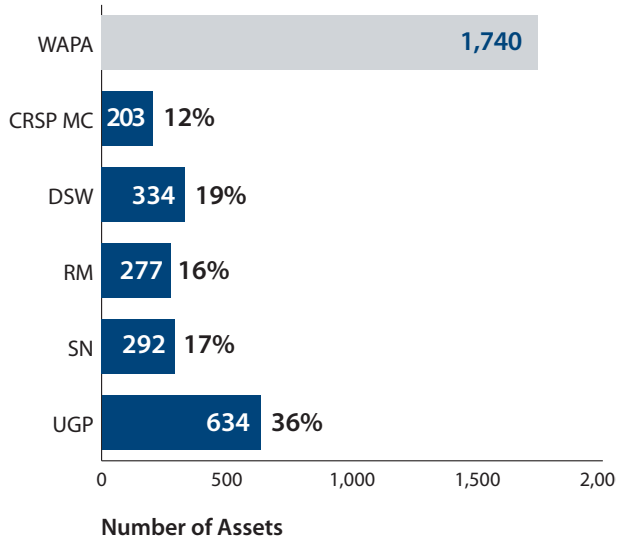
Commentary: The data is for reactive, corrective and emergency maintenance work combined. It does not include preventive maintenance.

POWER CIRCUIT BREAKERS

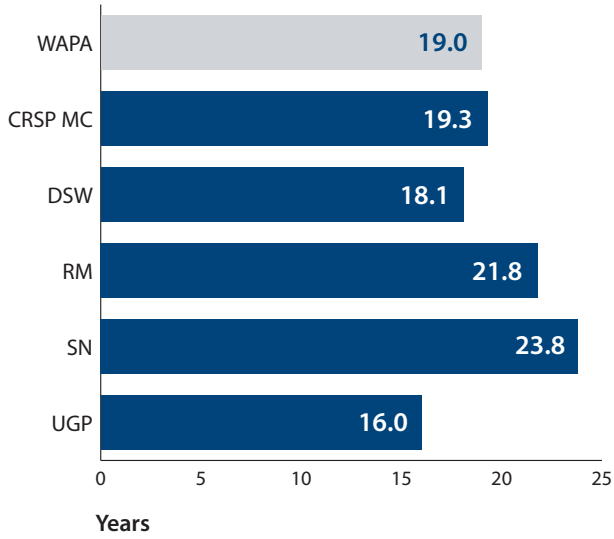
The circuit breaker asset class includes all oil, gas, air and vacuum breakers that are equal to or greater than 100 kV.

CIRCUIT BREAKER ASSETS OVERVIEW

Circuit Breaker Count by Region



Average Age of Circuit Breakers

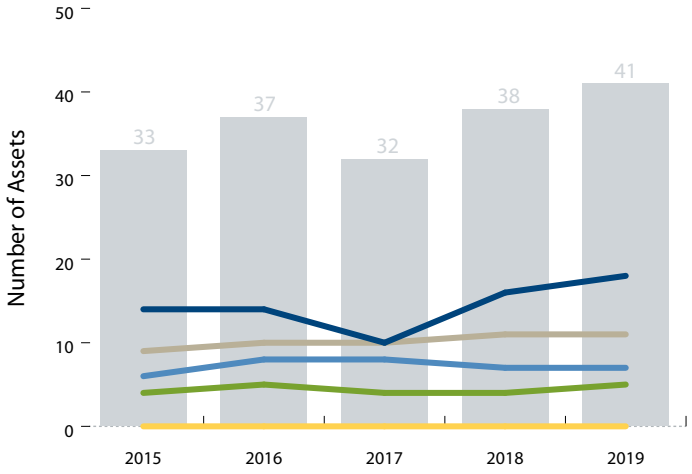


Electricians work on a 230-kV circuit breaker at Hilltop Substation.

CIRCUIT BREAKER ASSETS: RISK AND HEALTH INDEX OVERVIEW

Trend: Exceeds Risk

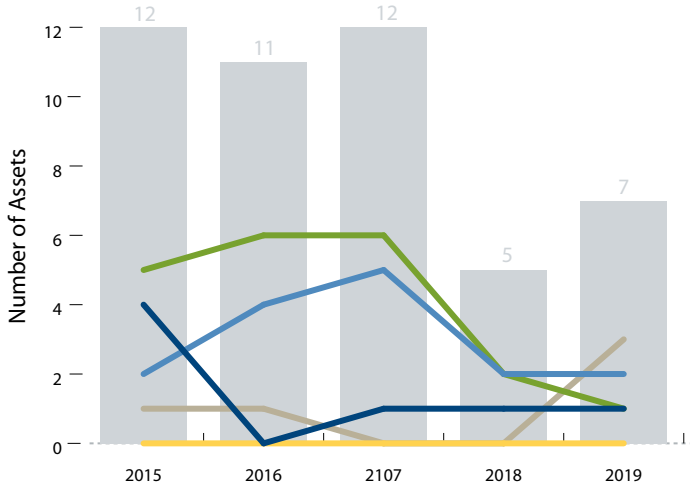
Threshold > 2



Commentary: Circuit breaker risk is quantified by understanding the consequence of asset failure within the transmission system and correlating that to individual asset health scores.

Trend: Below Health Index

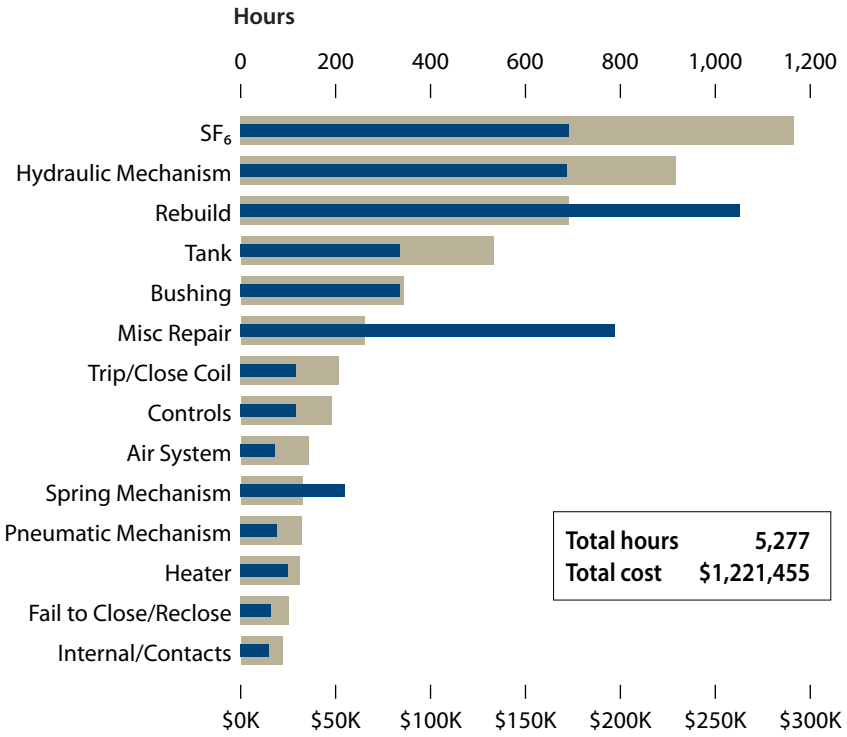
Threshold < 50



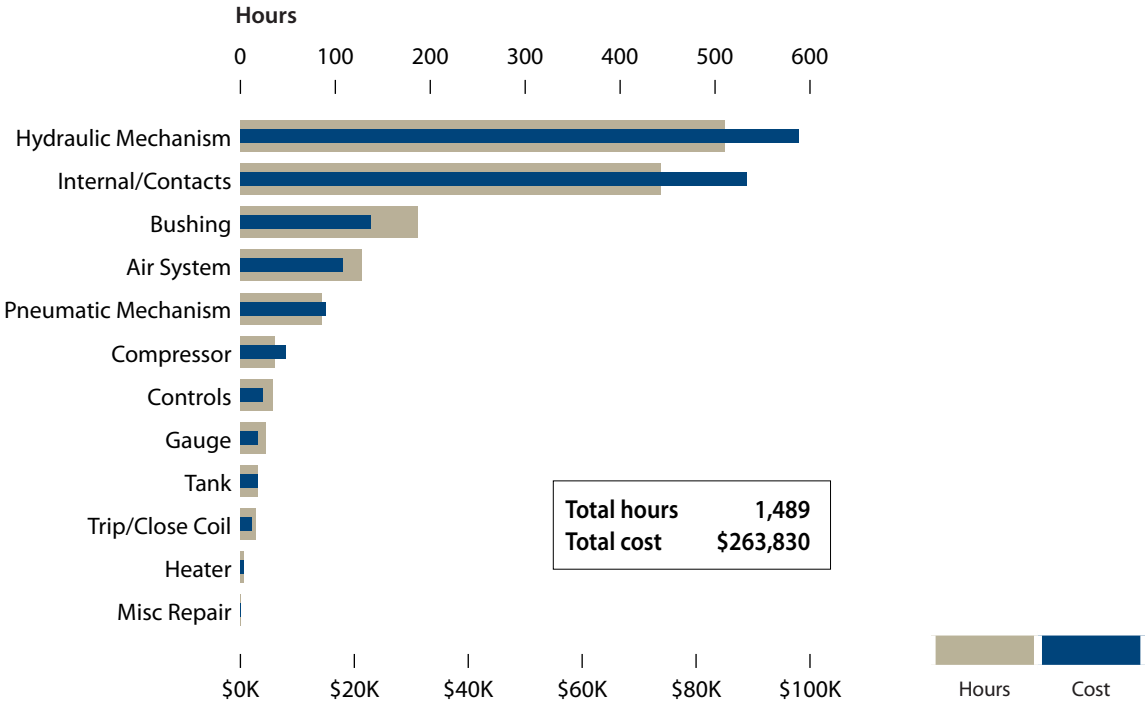
Commentary: The health of circuit breakers is determined by field information gathered on operations and maintenance history, power system stress, age or design factors and obsolescence.

POWER CIRCUIT BREAKER MAINTENANCE ITEMS

Gas Circuit Breakers

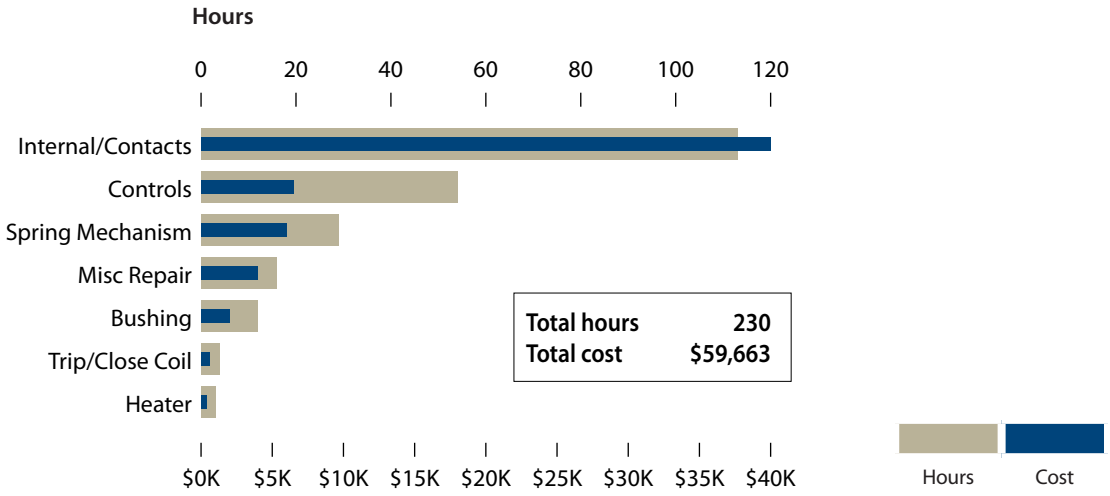


Oil Circuit Breakers



POWER CIRCUIT BREAKER MAINTENANCE ITEMS

Vacuum Circuit Breakers



Commentary: The data is for reactive, corrective and emergency maintenance work combined. It does not include preventive maintenance.

Phase-shifting transformers, like this one at Glen Canyon Dam, were among the first assets AM addressed, making it possible to streamline acquisition time for this critical equipment.

10-YEAR ASSET INVESTMENT PROJECTION

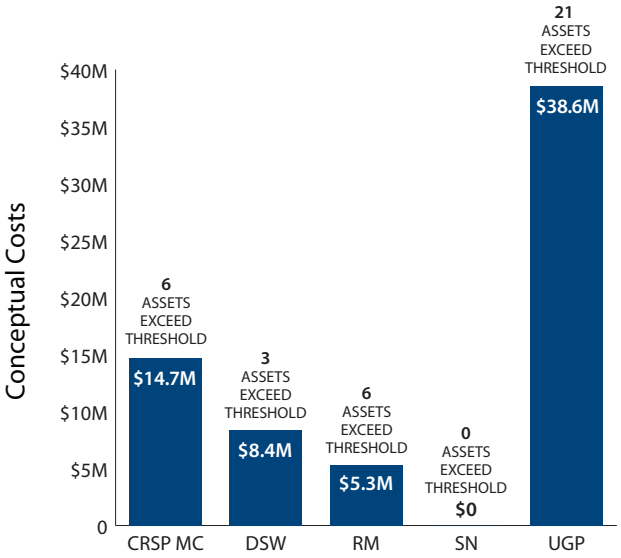
Asset Management developed the WAPA Asset Risk Estimator, or WARE, for 10-year asset investment projections. WARE considers the current known values and gives a projection for which assets will exceed threshold limits over the next 10 years.

AM evaluates existing health and risk thresholds annually based on input from stakeholders and subject matter experts. The thresholds establish actionable boundaries on mitigation for individual assets. Mitigation may include maintenance on the asset to bring it back within threshold, asset replacement or acceptance of the risk. The evaluations ensure that the data is validated against the observations and experience of the maintenance crews.

Assets identified by WARE as exceeding thresholds may not necessarily need replacement. Additional maintenance or accepting risk are options for mitigation.

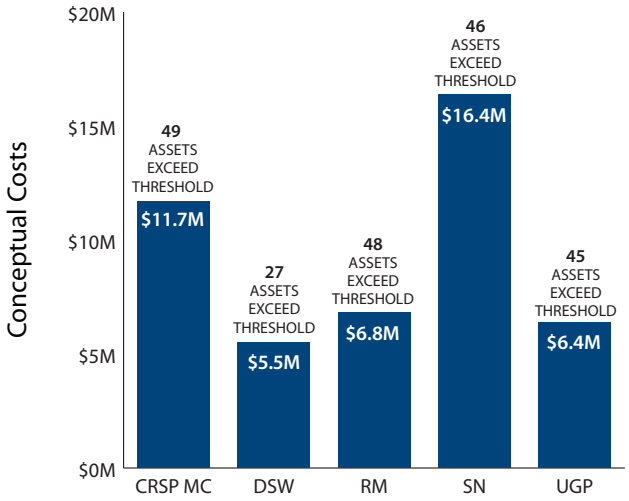
WARE RESULTS: POSSIBLE FUTURE INVESTMENT NEEDS

Possible Transformer Investment: 10-Year Outlook: 2019 – 2028



Commentary: The WARE tool projects asset replacement using current health and risk data for the current year, but only uses age data to extrapolate to future years. Mitigation options for assets that fall outside thresholds may include asset investment, replacement, additional maintenance or accepting the risk.

Possible Circuit Breaker Investment: 10-Year Outlook: 2019 – 2028



Commentary: The WARE tool projects asset replacement using current health and risk data for the current year, but only uses age data to extrapolate to future years. Mitigation options for assets that fall outside thresholds may include asset investment, replacement, additional maintenance or accepting the risk.

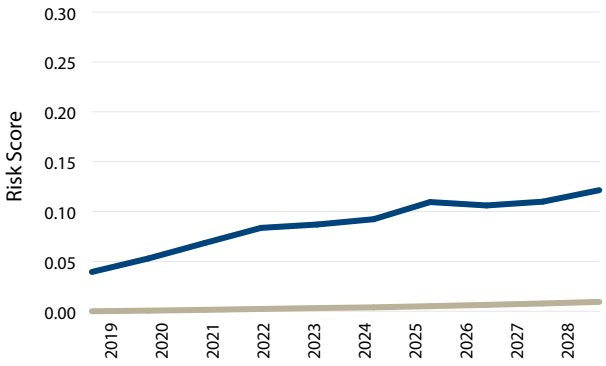
10-YEAR HEALTH AND RISK PROJECTION

Assets that fall outside of the established health and risk thresholds are identified for mitigation actions.

The graphs below show a projection of health and risk values for the respective assets if current thresholds are maintained.

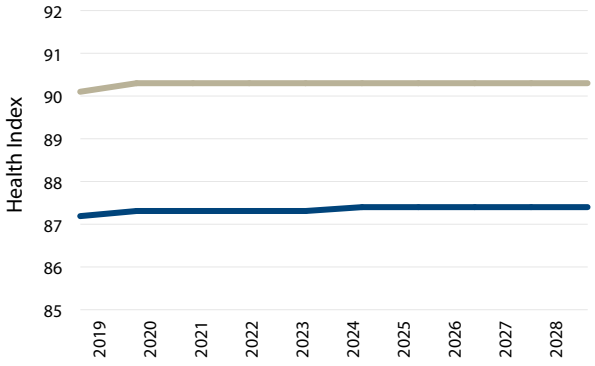
RISK AND HEALTH INDEX FORECAST

Transformer Risk Score Forecast



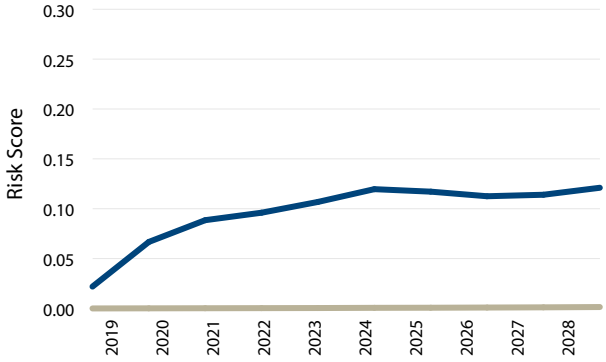
Commentary: If the current risk thresholds remain at current set points, risk scores trend upwards. Reducing the current thresholds may be a solution to the climbing trend.

Transformer Health Index Forecast



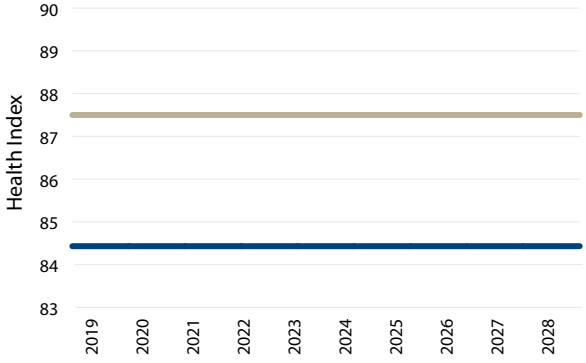
Commentary: Health forecasts remain steady and no adjustments to thresholds may be necessary.

Circuit Breaker Risk Score Forecast



Commentary: If the current risk thresholds remain at current set points, risk scores trend upward. Reducing the current thresholds may be a solution to the climbing trend.

Circuit Breaker Health Index Forecast



Commentary: Health forecasts remain steady and no adjustments to thresholds may be necessary.

Average Median

RELIABILITY-CENTERED MAINTENANCE

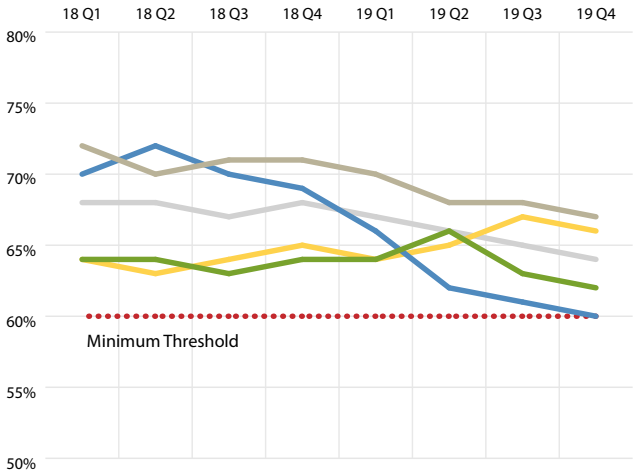
Reliability-centered maintenance, or RCM, is a systematic approach to developing an optimal maintenance strategy that focuses on preserving important power system equipment functions. WAPA's RCM program asks:

- What equipment is critical to the reliable operation of the power system?
- What breaks and why?
- How do we prevent it from breaking again?

The data collected by maintenance crews as part of WAPA's RCM program answer these questions, laying the foundation for effective maintenance planning and management as well as justification of maintenance decisions.

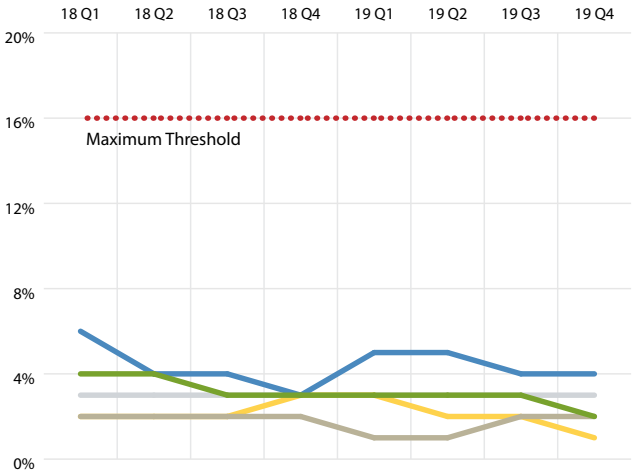
CREW HOURS OVERVIEW AS OF FYE 2019

Percent Direct: 2-Yr Trend of the 4-Qtr Moving Average



Commentary: This graph represents the percentage of time crews in each region and WAPA as a whole perform direct work on WAPA assets, also known as wrench time. Wrench time includes preventive, reactive, corrective and emergency maintenance; construction; minor additions, enhancements and retirements; and operations support. AM established the goal of 60% or more crew time for direct work based on industry benchmarking. Maximizing crew time for performing direct work is a measure of resource management effectiveness. Rocky Mountain and Desert Southwest regional Maintenance organizations maintain the assets of the Colorado River Storage Project Management Center (approximately 12% of WAPA's major assets), which are included in the graph.

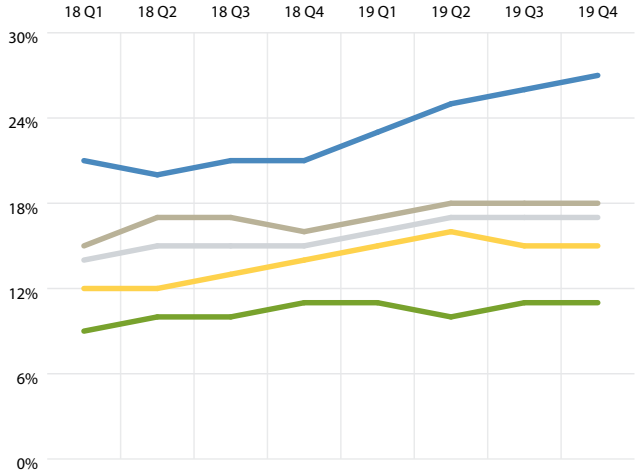
Percent Repair: 2-Yr Trend of the 4-Qtr Moving Average



Commentary: This graph represents the total percentage of time crews in each region and WAPA as a whole perform emergency and corrective maintenance on WAPA assets, versus planned preventative and follow-up maintenance activities. AM established the goal of 16% or less crew time for repairs based on industry benchmarking. This metric provides an indication of the overall effectiveness of the RCM program. An inadequate maintenance program would result in an increase of crew time spent on failing equipment, leading to a higher percentage of unplanned maintenance. Some cases of emergency and corrective maintenance may be attributed to causes beyond RCM control, such as extreme weather or fire. Starting in FY 2019, those hours were designated as "external event" and were removed from the formula to provide a more accurate picture of percent repair within control of a maintenance program. RM and DSW regional maintenance organizations maintain CRSP MC assets (approximately 12% of WAPA's major assets), which are included in the graph.

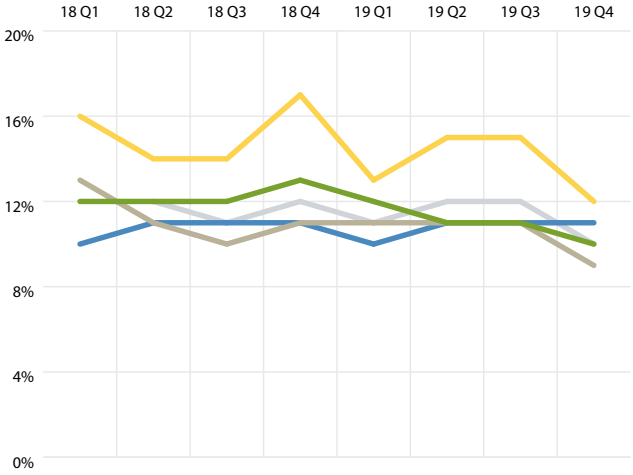
CREW HOURS OVERVIEW AS OF FYE 2019

Percent Administrative: 2-Yr Trend of the 4-Qtr Moving Average



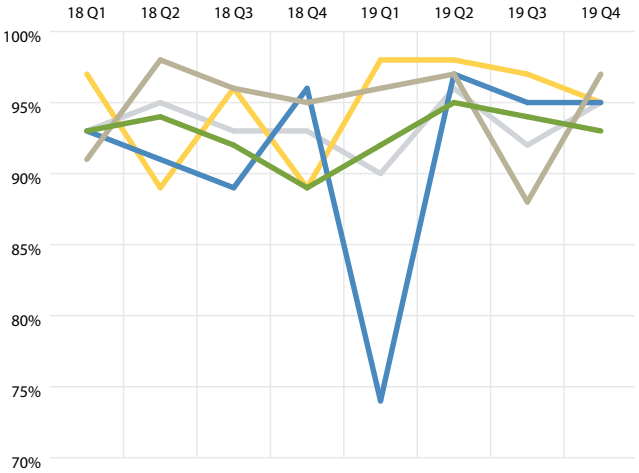
Commentary: This graph represents the total percentage of time crews in each region and WAPA as a whole perform administrative duties. Administrative duties include work activity such as drawing updates, general engineering support, credit-card reconciliation and timekeeping. Training and compliance activities such as training, attending meetings, union activities, safety and security investigations and environmental inspections are also in this category. Although no official goal has been established, 25% or less is considered acceptable due to the amount of training and compliance activities (safety, environmental, North American Electric Reliability Council, Western Electricity Coordinating Council, etc.) mandated for maintenance Craft teams. Minimizing administrative duties of Craft personnel results in better use of the employee skillset. Administrative work is tied to maintenance organizations rather than specific assets.

Percent Overtime: 2-Yr Trend of the 4-Qtr Moving Average



Commentary: This graph represents the total percentage of time crews in each region and WAPA as a whole perform work while in overtime. Although there is no set goal for this metric, tracking percent overtime gives a fair indication of resource (personnel) needs and system health. An excess of scheduled overtime indicates the need for more full-time employees, while excessive unscheduled overtime suggests problems with system health as emergency-type work often occurs during typically non-working hours (overtime). Weather and other non-maintenance-related emergencies also result in overtime, and many extreme weather events occurred in 2019. RM and DSW regional maintenance organizations maintain CRSP MC assets (approximately 12% of WAPA's major assets), which are reported with these regions in the graph.

Percent RCM: 2-Yr Trend of the 4-Qtr Moving Average



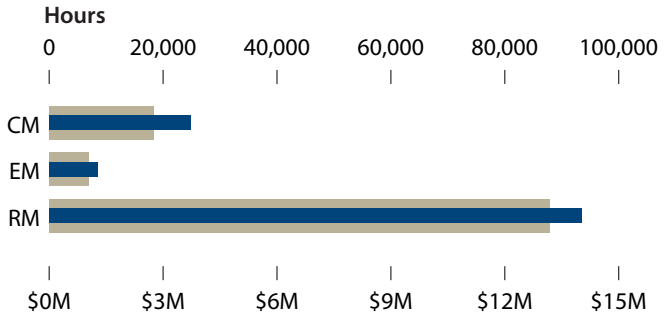
Commentary: This graph measures WAPA's ability to maximize preventive and reactive maintenance work (typically a planned follow-up to issues discovered during preventive maintenance) over corrective and emergency maintenance and is a key performance indicator for WAPA's RCM program. There are no industry standards published for this metric; however, WAPA has established its own standard based on historical data gathered over the past 15 years. Reactive maintenance that represents 90% or more of maintenance work indicates a successful RCM program. Falling below that threshold triggers an action plan to address program improvements. RM and DSW regional maintenance organizations maintain CRSP MC assets (approximately 12% of WAPA's major assets), which are included in the graph. DSW experienced a high number of hardware failures during FY 2019 Quarter 1. Such fluctuations are typically related to seasonal conditions.

REACTIVE, CORRECTIVE AND EMERGENCY MAINTENANCE CATEGORIES AND COSTS

Maintenance-related work orders fall into four categories:

- Preventive maintenance is planned work intended to predict, prevent or detect asset and component failure or progression to failure. This work at WAPA is based primarily on time intervals but can also be determined by counter readings, system events or asset condition.
- Reactive maintenance occurs when PM or a remote indicator alarm uncovers a degraded condition on a functioning asset that can be addressed before the asset's function fails. Since the asset is still functioning as intended, the repair can be planned and scheduled.
- Corrective maintenance fixes a problem that has caused an asset to fail in its intended function. This type of failure is not detected through PM or alarm indication, making unplanned repairs necessary to restore the asset to its intended functionality. It differs from emergency maintenance in that the problem, while imminent, does not require immediate attention. Corrective maintenance is typically follow-up work to emergency maintenance.
- Emergency maintenance mitigates a sudden disruption of the power system or other emergency condition and either restores unexpected loss of essential functions or mitigates the emergency condition. EM warrants cessation of other assigned work and may result in sending crews out after hours. While EM focuses on immediate restoration or mitigation measures, CM work typically follows EM to repair the item that caused the emergency condition.

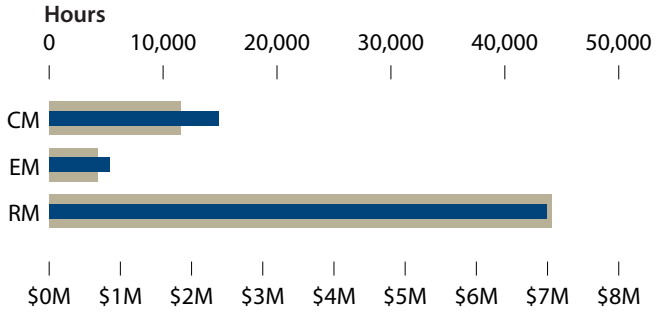
Overview of RM, CM, EM Hours and Cost



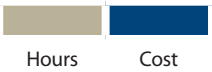
Total hours 113,062
Total cost $19,024,646

Commentary: This graph represents the total dollars and hours WAPA spent performing RM, CM and EM work outside of planned preventative maintenance on all equipment for calendar year 2019. Transmission lines, substation equipment, transformer-type equipment and circuit breakers represent a portion of WAPA's total equipment assets.

Transmission Line RM, CM, EM Hours and Cost

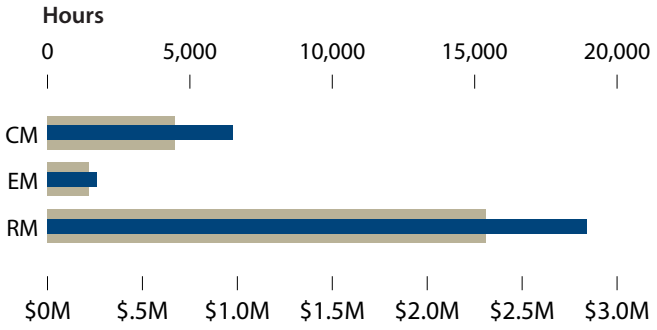


Total hours 59,887
Total cost $10,229,416



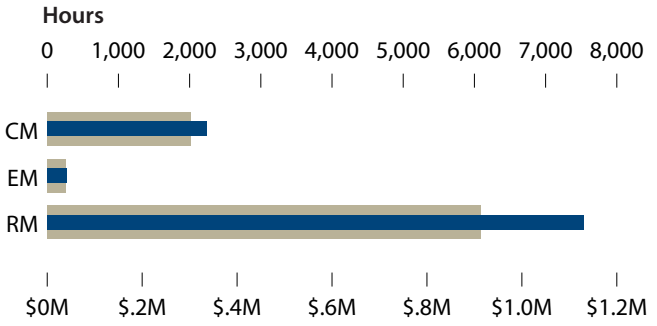
REACTIVE, CORRECTIVE AND EMERGENCY MAINTENANCE CATEGORIES AND COSTS

Substation Equipment RM, CM, EM Hours and Cost



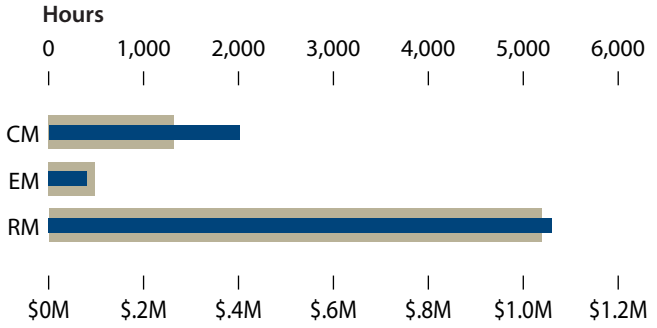
Total hours	**21,331**
Total cost	**$4,080,396**

Transformer-Type Equipment RM, CM, EM Hours and Cost



Total hours	**8,379**
Total cost	**$1,509,108**

Circuit Breaker RM, CM, EM Hours and Cost



Total hours	**6,996**
Total cost	**$1,544,948**

In 2020, WAPA will update its failure-coding system, the standard terminology that describes equipment problems observed in the field. This effort will improve equipment performance analysis and consistently communicate asset data within WAPA's maintenance community. Failure-code reporting currently applies only to circuit breakers, power transformers, phase-shifting transformers and oil-filled reactors; expansion to other substation equipment is expected over the next few years.

DATA COMMUNICATION

Asset Management reports and analyses can only shape business- and capital-planning decisions if stakeholders use them. The AM Communication Plan builds awareness of program products and activities by identifying opportunities to meet and engage with specific stakeholder groups. AM staff regularly make presentations to key councils and WAPA departmental meetings to educate diverse audiences about AM data collection and to learn more about stakeholders' data needs. Stakeholder groups include:

INTERNAL

- Senior Leadership Team.
- Regional rate-setting organizations.
- Financial Leadership Council.
- Power Marketing Management Council.
- Power System Operations Council.
- WAPA Maintenance Management Council.
- Information Technology Senior Leadership Team.
- Acquisition Collaboration Team.
- Regional Asset Management specialists.
- Regional capital planning groups.
- Administrative Services Council.

EXTERNAL

- Customers and regional and membership groups representing them.
- North American Transmission Forum.
- Electric Power Research Institute.
- Regional capital planning groups.
- Technical committees.
- Engineering and operating committees.

DATA VALIDATION

Accurate and dependable data is central to instilling the confidence stakeholders need to accept asset management reports as a basis for decision making. Validating data is carried out in two ways:

- Quantitatively – Reports on incorrect and missing data are prepared monthly to identify gaps in asset data that may be skewing asset health or risk scores.
- Qualitatively – Knowledgeable field crews corroborate asset management data as needed to ensure asset scoring is representative of actual field conditions.

CONTACT AM

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A lattice transmission structure at Glen Canyon Dam is exposed to a very different environment than the same structure in Nebraska. AM's condition-based health index captures these differences better than age-based assessment.

Western Area
Power Administration

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U.S. DEPARTMENT OF
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