

VALUE OF ASSET MANAGEMENT

INTRODUCTION

The Office of Asset Management is WAPA's functional implementation of the structured philosophy of ISO 55000, the international standard for the management of assets.

Asset Management uses asset information gathered from field crews and subject matter experts during routine work activities to produce valuable data products, which are then used in capital planning, maintenance procedure decisions and other business decisions requiring risk-based analysis.

Assets being evaluated for health and risk include:

- Transmission lines \geq 100-kV
- Power circuit breakers \geq 100-kV
- Power transformers
- Phase-shifting transformers
- Oil-filled reactors
- Grounding transformers



ABOUT ASSET MANAGEMENT

Asset Management (AM) provides data-driven insight on enterprise assets. This insight supports informed decision making on budget development, capital plans, financial forecasting, maintenance practices, system resilience, reliability, safety and security.

AM creates value by combining extensive field knowledge with insights gained from significant and actionable data. Growth is focused on the following areas:

- Asset analytics
- Data quality
- Risk-management tools
- Additional asset classes for analytics

In addition to asset performance metrics, employees also contribute valuable engineering data and expertise to develop safety manuals and procedures used by field crews.

OBJECTIVES

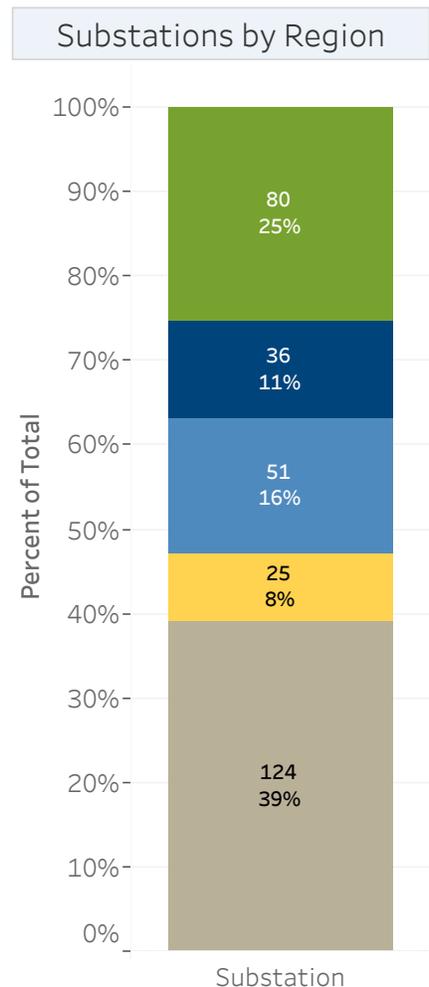
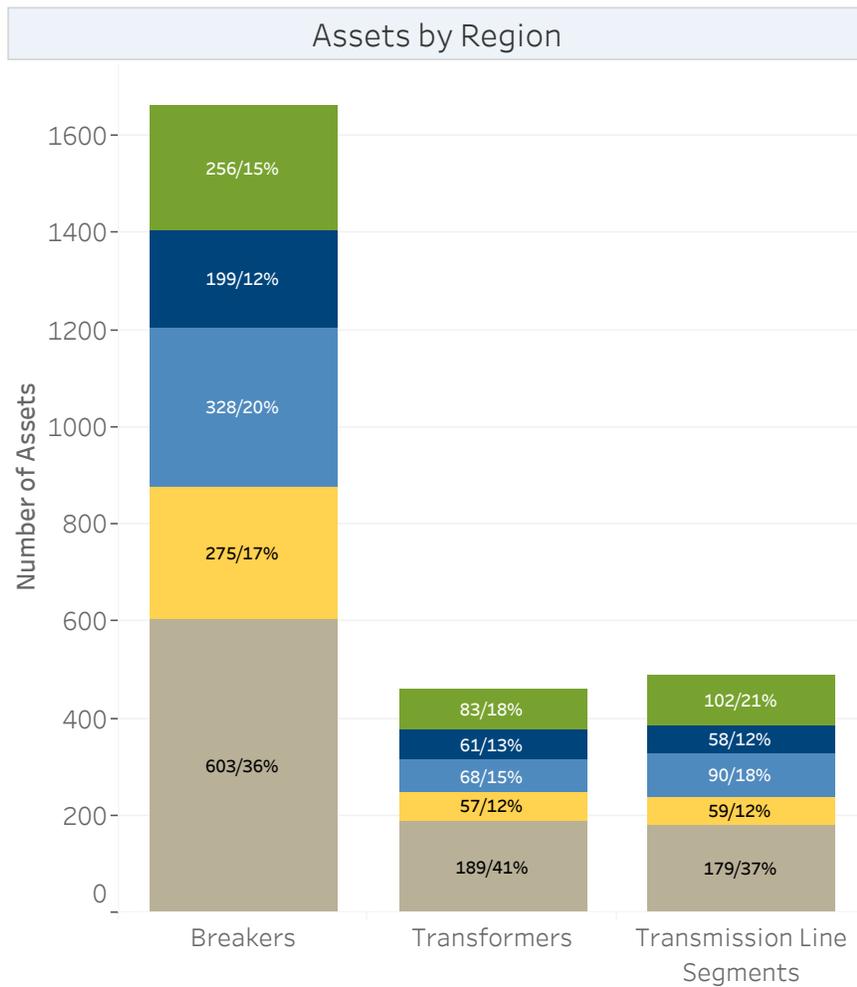
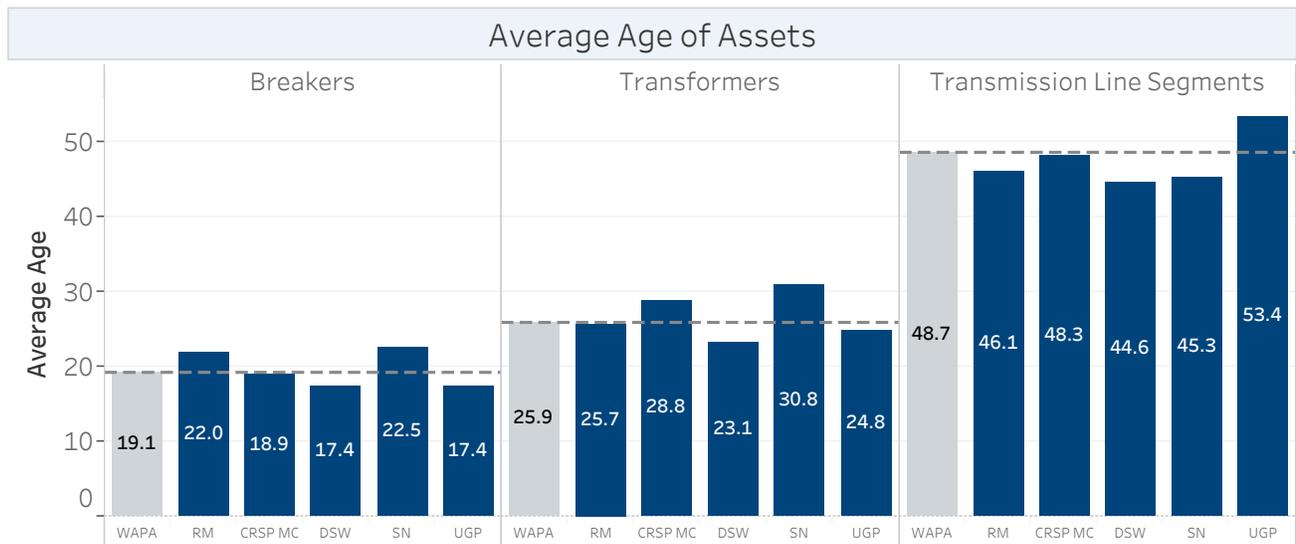
- Integrate all value-added assets into risk-based methodologies to strategically inform capital investments
- Maximize value of assets
- Correlate asset risk to transmission resilience
- Use asset performance data to inform best maintenance practices

PRIORITIES

- Strategically source, collect and use data to inform investment decisions
- Validate data
- Effectively communicate data internally and externally



WAPA ASSETS AT A GLANCE



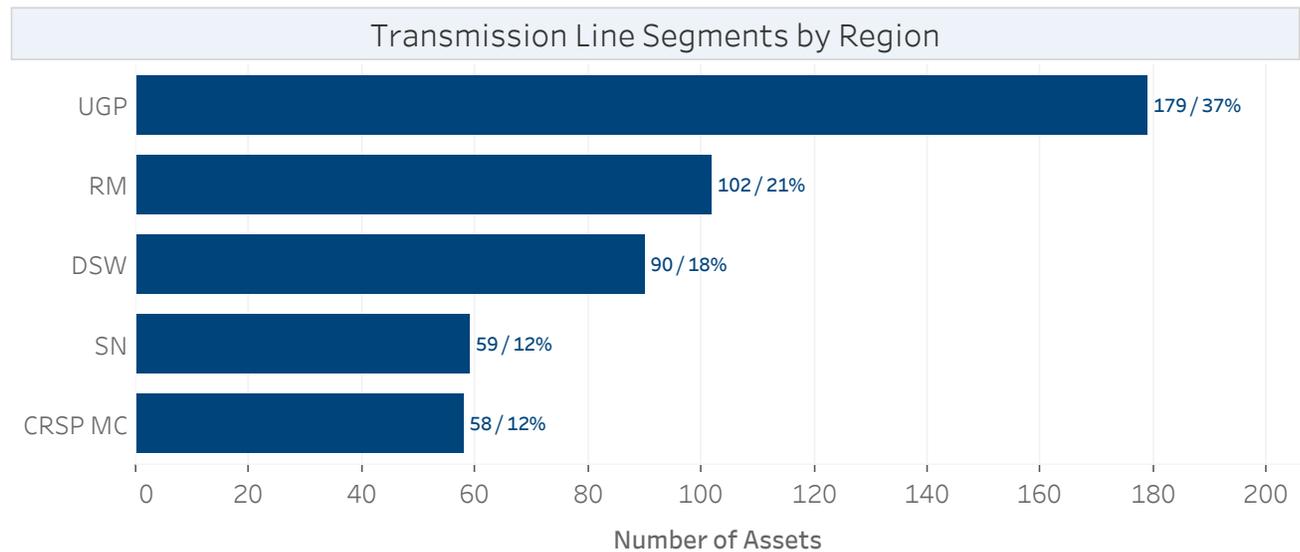
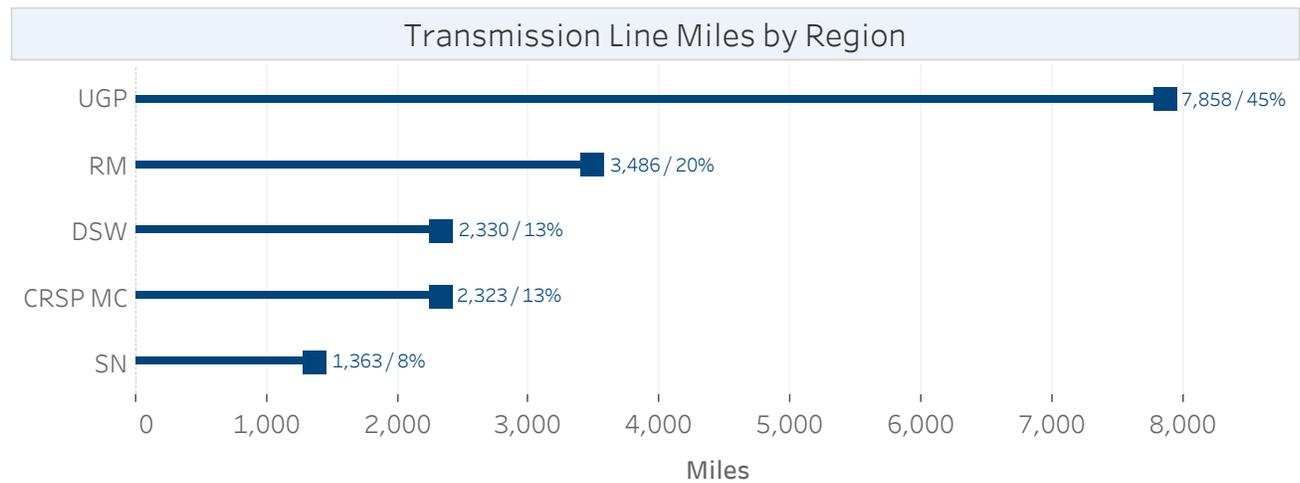
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ASSET PERFORMANCE DATA

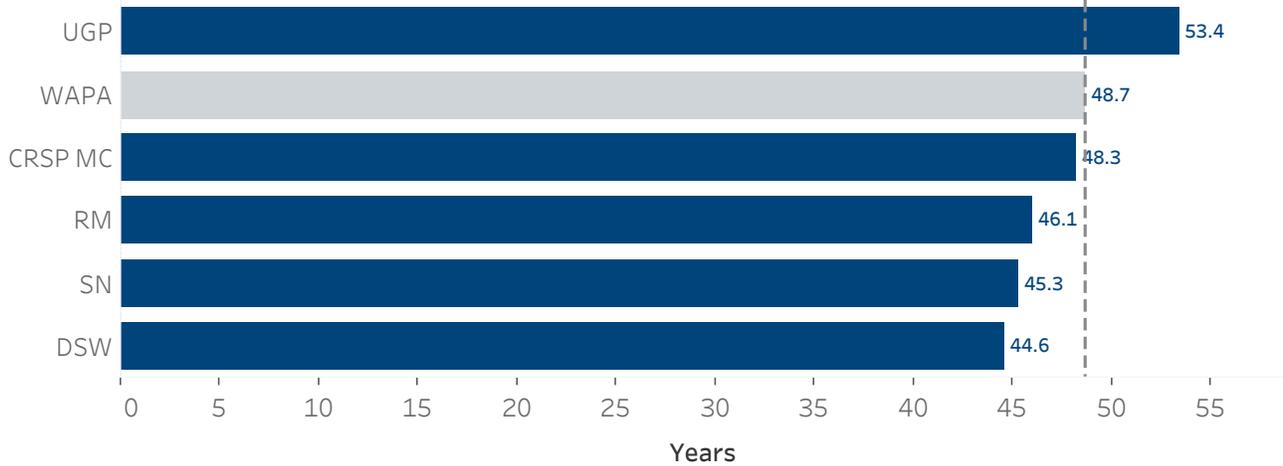
TRANSMISSION LINES

AM formally introduced a condition-based health index for transmission lines greater than or equal to 100-kV for 514 line segments, moving away from age-based assessments. Routine inspection performance ratings on individual structures now drive health-index algorithms to ensure field knowledge is gathered and integrated to determine the condition of WAPA's transmission line fleet. Risk and health trends for transmission lines will not be reported in 2018 because their performance criteria was reestablished using the condition-based method mentioned above.

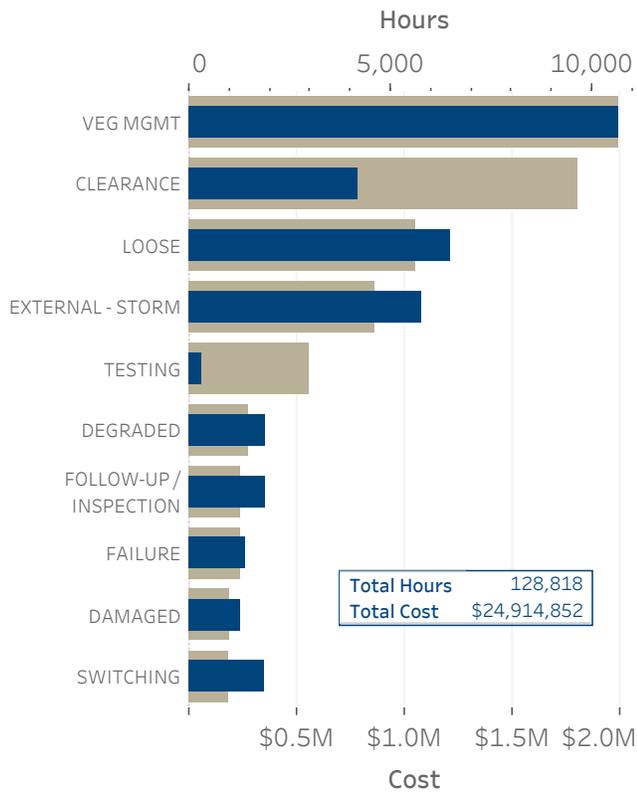
Transmission Line Assets Overview



Average Age of Transmission Lines



Transmission Lines Maintenance Items



Commentary:

Chart above currently excludes "UNKNOWN," which accounts for **88,234 Hours** and **\$16.8M in costs**. "UNKNOWN" will be resolved with improved failure coding, which is already in progress.

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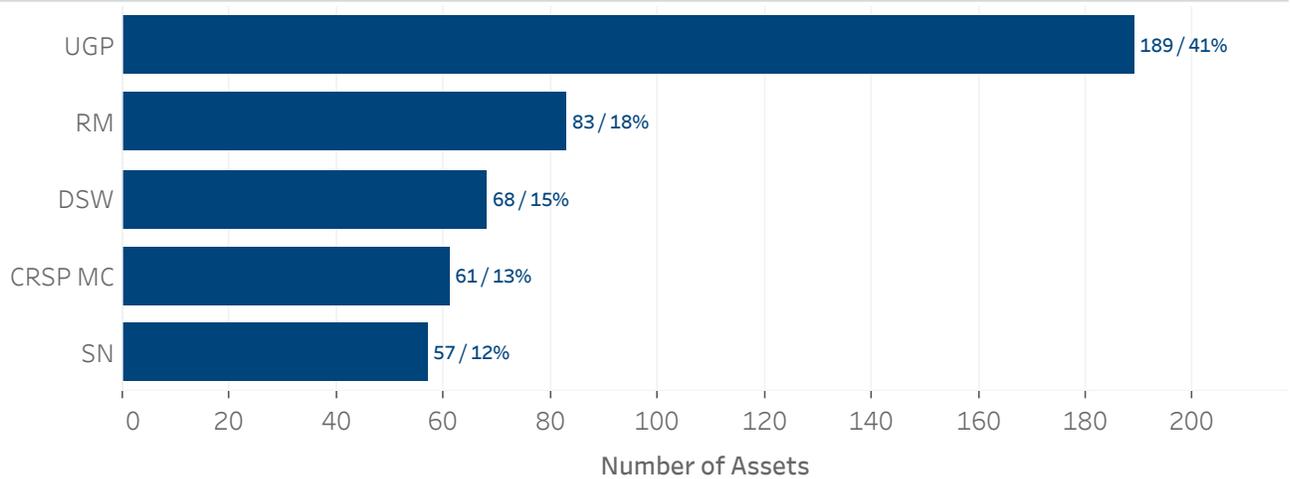
- Total Cost
- Total Hours

TRANSFORMERS

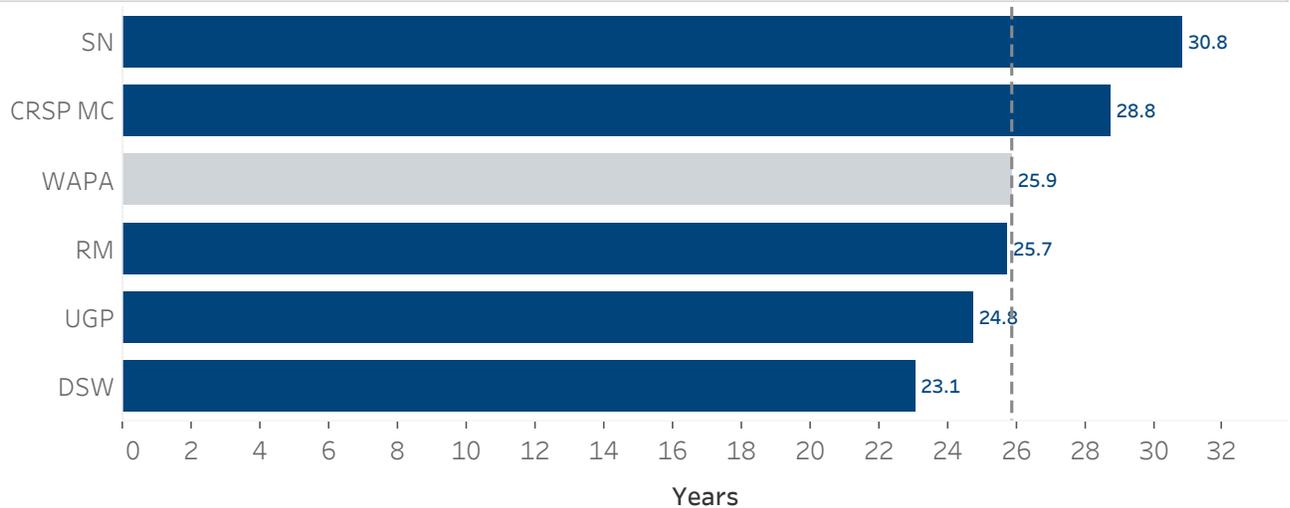
The asset class of transformers includes power transformers, grounding transformers, oil-filled reactors and phase-shifting transformers. Single-phase assets are typically considered stand-alone assets when part of a three-phase bank.

Transformer Assets Overview

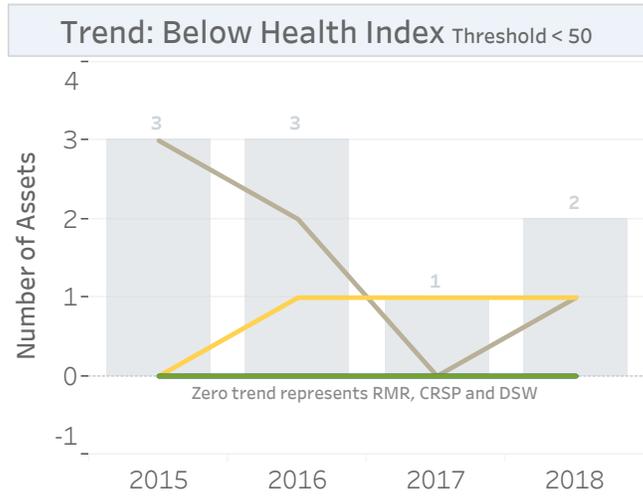
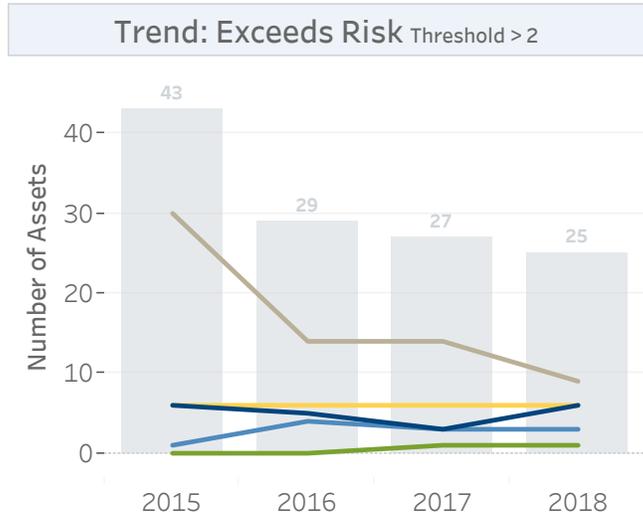
Transformer Count by Region



Average Age of Transformers



Transformer Assets: Risk and Health Index Overview

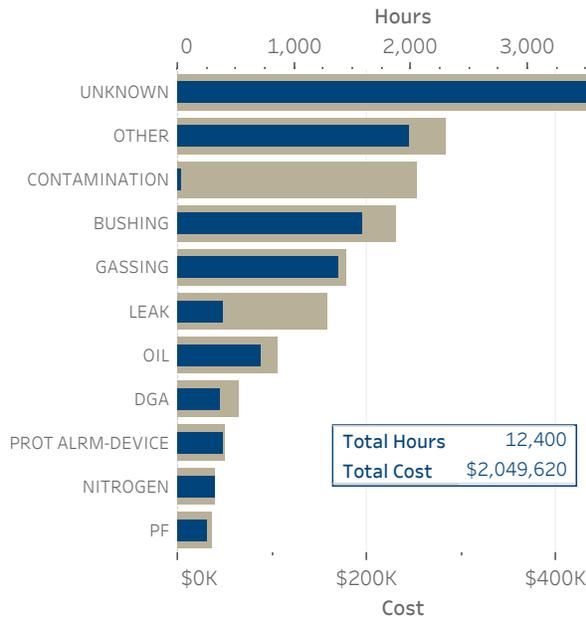


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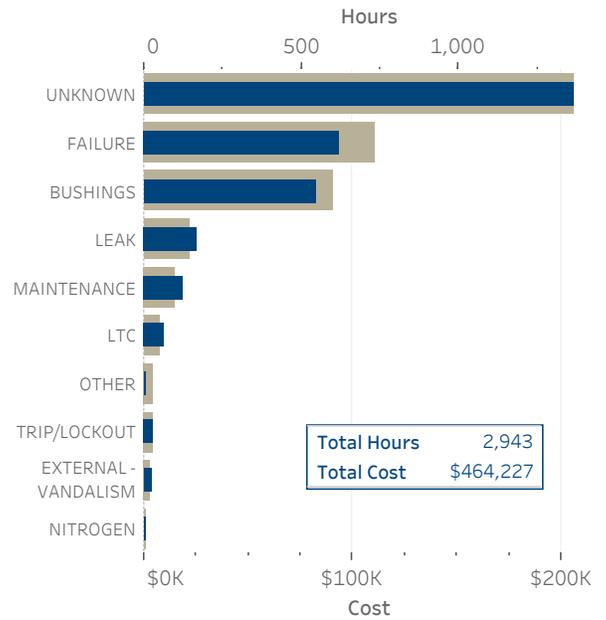
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- CRSP MC
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Transformer Maintenance Items

Power Transformers

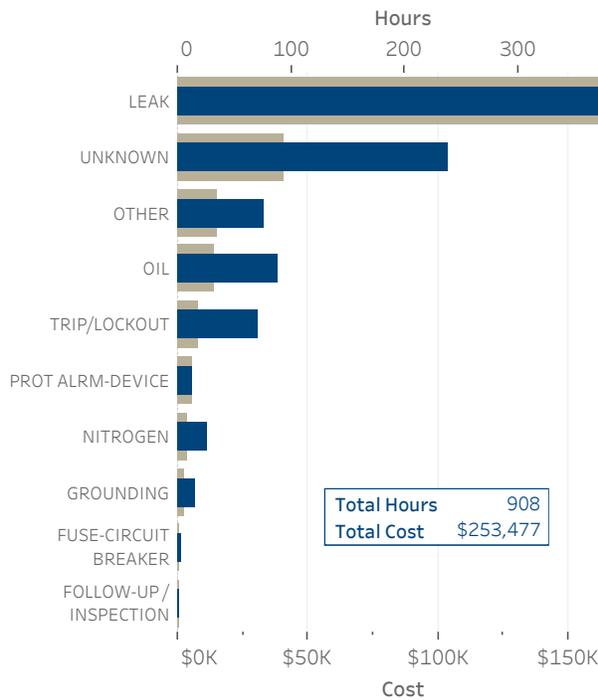


Mobile Transformers

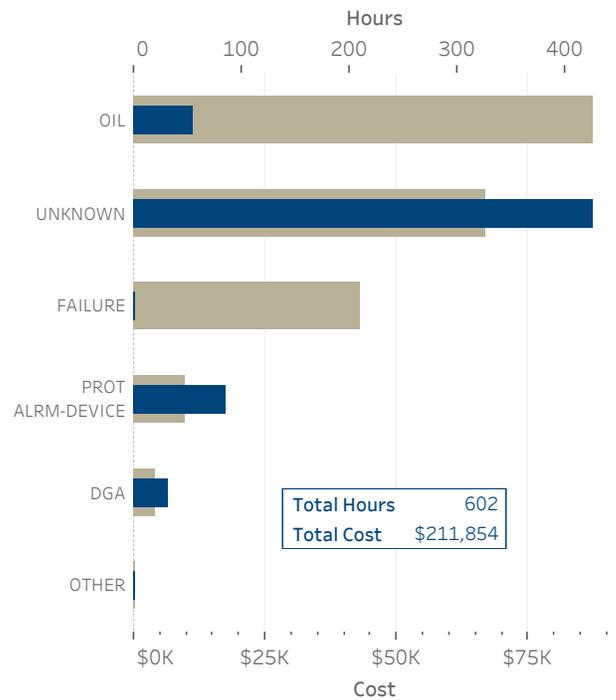


Commentary:
Failure refers to a bushing failure.

Oil Filled Reactors



Phase-Shifting Transformers

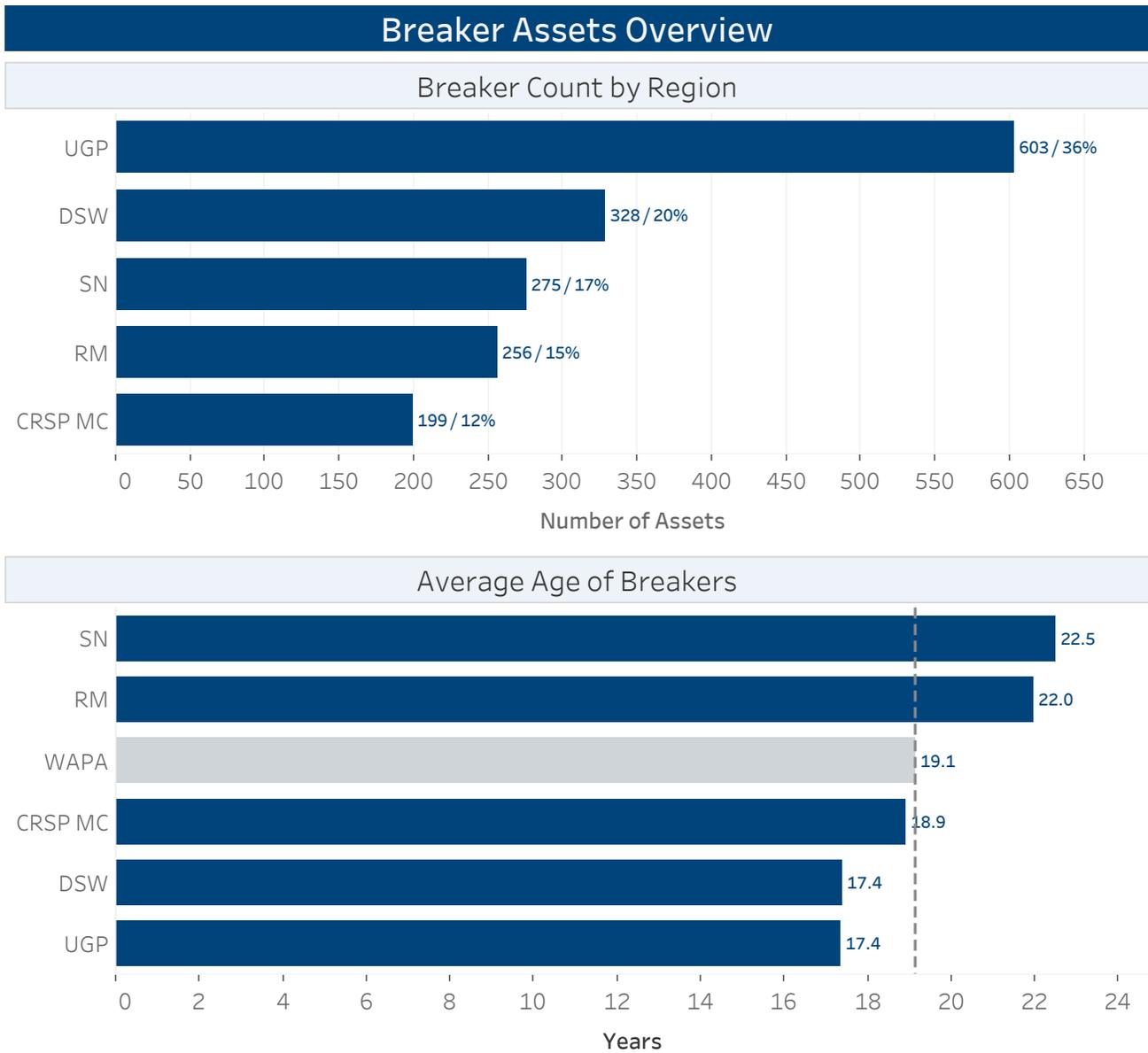


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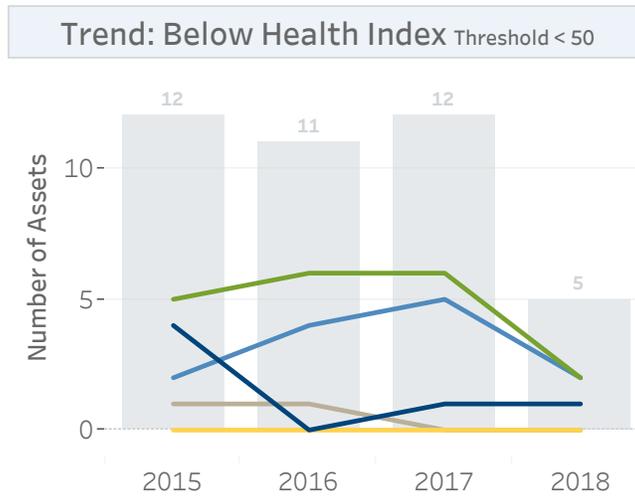
Color Legend/Measure:
■ Total Cost
■ Total Hours

POWER CIRCUIT BREAKERS

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



Circuit Breaker Assets: Risk and Health Index Overview

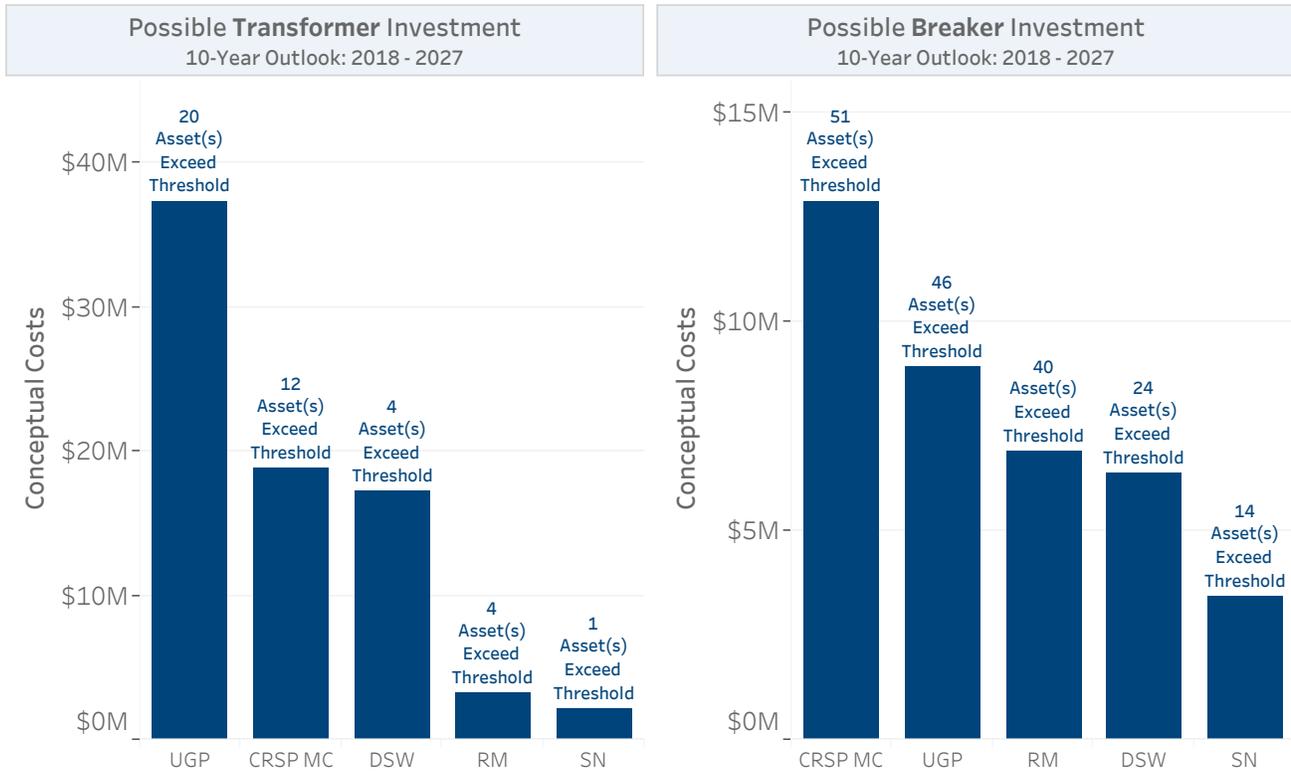


Color Legend / Regions:
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10-YEAR ASSET INVESTMENT PROJECTION

AM developed the WAPA Asset Risk Estimator, or WARE, for 10-year asset investment projections. WARE considers the current known risk values and projects which assets will exceed threshold limits over the next 10 years. Thresholds for health and risk are established annually based on WAPA’s risk tolerance and capability for mitigation. Assets identified by WARE may be single-phase assets within a three-phase bank.

WARE Results: Future Investment Needs



Commentary:

Replacement data is generated by the WARE tool, which uses current health and risk data for the current year, but only uses age data to extrapolate to out years. In addition, asset investment or replacement may not be the only mitigation option as identified in these graphs. Maintaining the asset back into acceptable thresholds or accepting the risk may also be a mitigation strategy.

Commentary:

Replacement data is generated by the WARE tool, which uses current health and risk data for the current year, but only uses age data to extrapolate to out years. In addition, asset investment or replacement may not be the only mitigation option as identified in these graphs. Maintaining the asset back into acceptable thresholds or accepting the risk may also be a mitigation strategy.

*Data for transmission lines will be available starting in 2019.

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

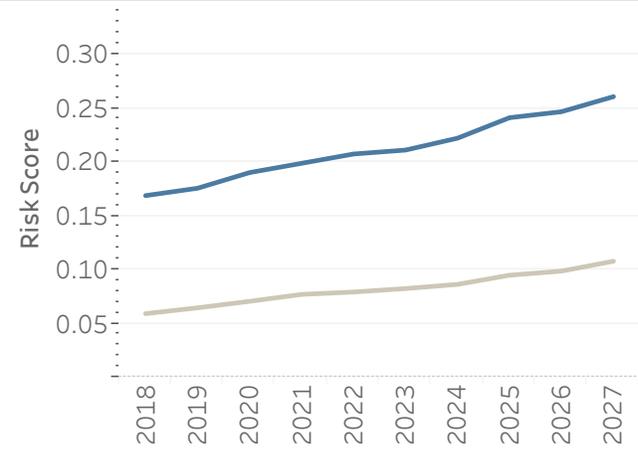
10-YEAR HEALTH AND RISK PROJECTION

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

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

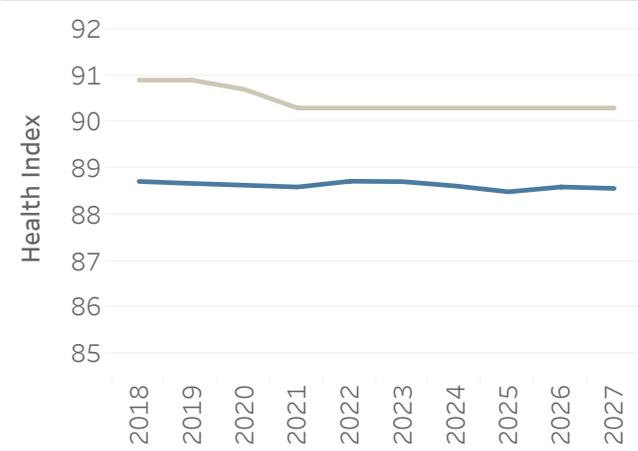
Risk and Health Index Forecast

Transformer Risk Score Forecast



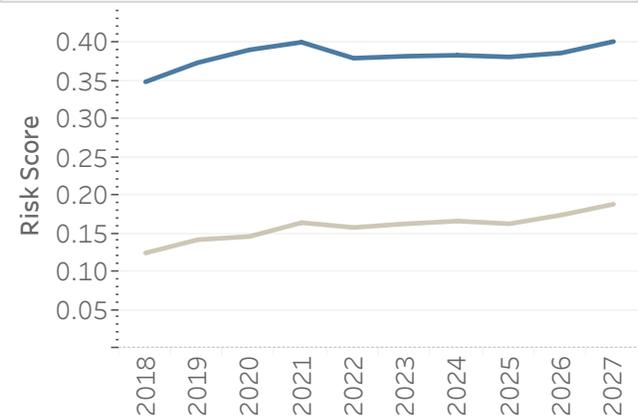
Commentary:
If the current risk thresholds remain at current set points, risk scores trend upwards. Reducing the current thresholds may be a solution to the climbing trend.

Transformer Health Index Forecast



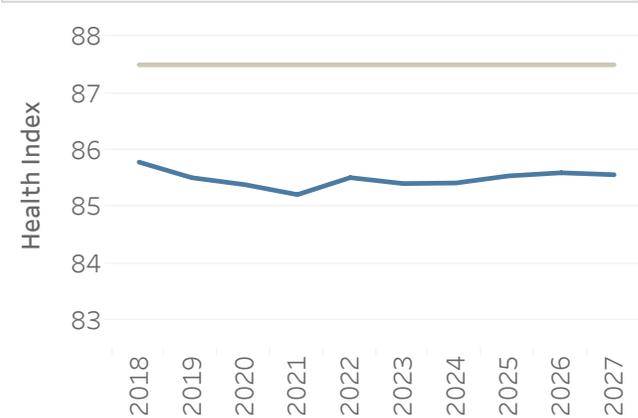
Commentary:
Health forecasts remain steady and no adjustments to thresholds may be necessary.

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.

Breaker Health Index Forecast



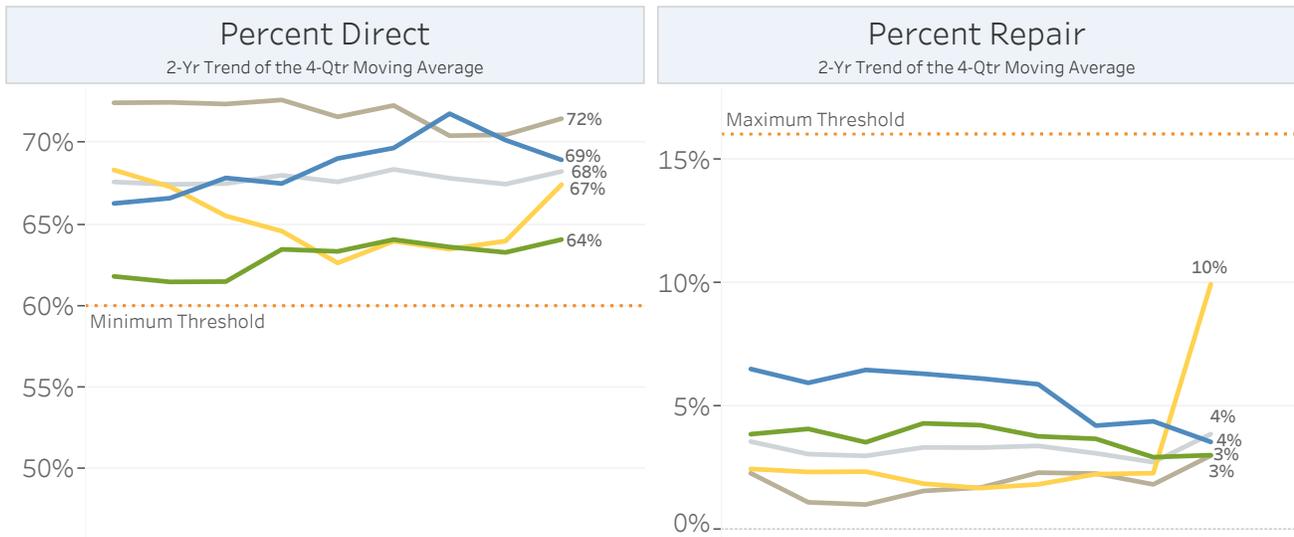
Commentary:
Health forecasts remain steady and no adjustments to thresholds may be necessary.

■ Average
■ Median

RELIABILITY-CENTERED MAINTENANCE

Reliability-centered maintenance, or RCM, is a systematic approach to routine maintenance that focuses on preserving important power system equipment functions. WAPA's RCM program is based on studies that technically evaluate equipment failure modes and causes as well as identify ways these failures can be prevented. The outcome of these studies are lists of preventive maintenance tasks to be performed at specified time intervals on substation equipment and transmission lines. Spikes in Sierra Nevada regional data are due to the Carr Fire.

Crew Hours Overview as of FYE 2018



Commentary:

This is a graphical representation of the percent of time crews in each region and WAPA as a whole perform direct work on WAPA assets (wrench time). Wrench time includes preventive maintenance, emergency maintenance, reactive maintenance, corrective maintenance, construction, operations support, and minor additions, enhancements, and retirements. A goal of 60 % or higher has been established based on industry trending. Maximizing crew time for performing direct work is a measure of resource management effectiveness.

Commentary:

This is a graphical representation of the total percent of time that crews in each region and WAPA as a whole perform emergency and corrective maintenance on WAPA assets. A goal of 16% or less has been established based on industry trending. Capturing this metric provides an indication of the overall effectiveness of the Reliability-Centered Maintenance program. A poor maintenance program would result in an increase of crew time expended on failing equipment, although in some cases emergency and corrective maintenance may be attributed to causes beyond RCM control.

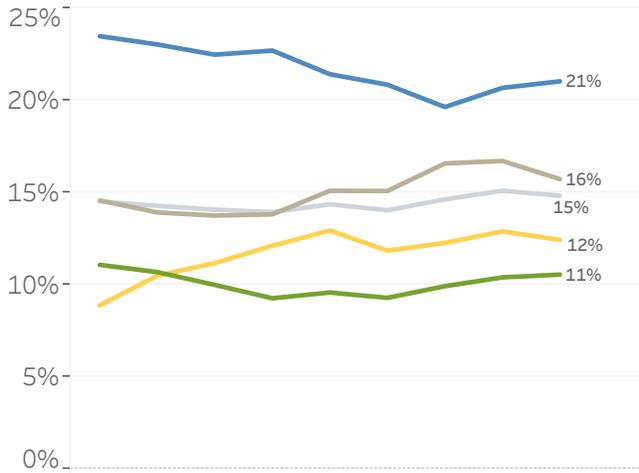
Color Legend / Regions:

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- WAPA

Crew Hours Overview as of FYE 2018

Percent Administrative

2-Yr Trend of the 4-Qtr Moving Average

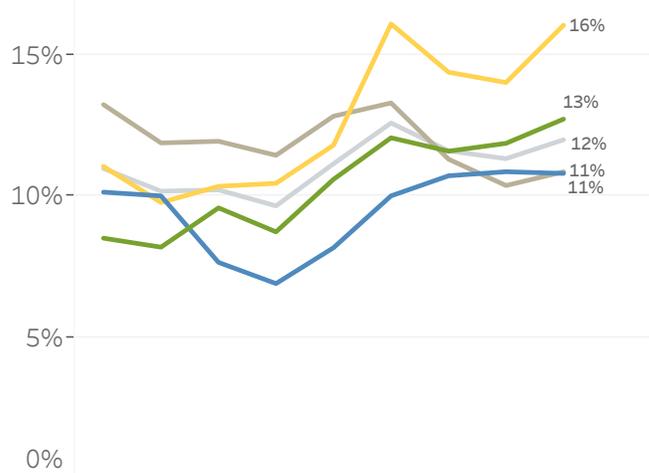


Commentary:

This is a graphical representation of the total percent of time that crews in each region and WAPA as a whole perform administrative duties. Administrative duties include performing “paperwork” such as drawing updates, general engineering support, credit card reconciliation, timekeeping, as well as human resource-related duties including training, attending meetings, union activities, safety and security investigations and environmental inspections. Although no hard goal has been established, 25% or less is considered acceptable on account of the amount of training and compliance activities (safety, environmental, NERC, WECC, etc.) are imposed on maintenance craft forces. Minimizing administrative duties of craft personnel results in better use of the employee skillset.

Percent Overtime

2-Yr Trend of the 4-Qtr Moving Average



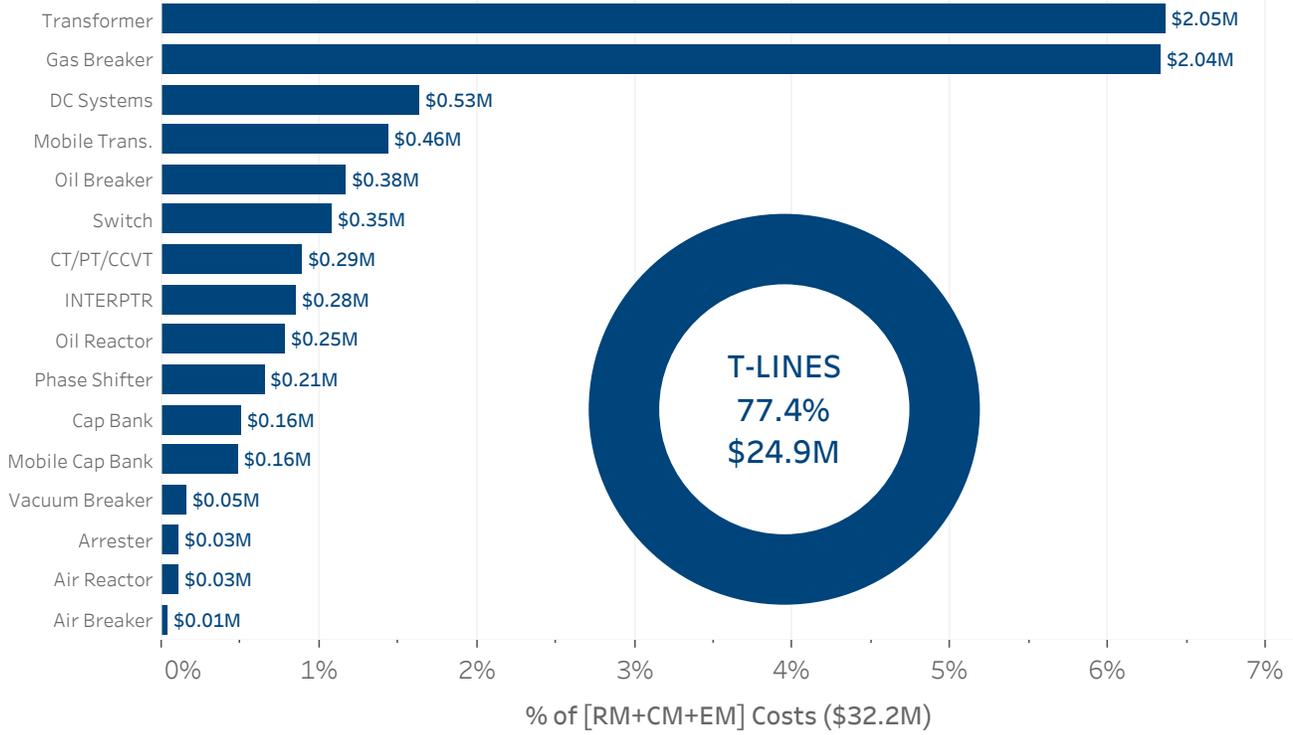
Commentary:

This is a graphical representation of the total percent of time that crews in each region and WAPA as a whole perform any work while in overtime. Although there is no set goal for this metric, tracking percent overtime gives a fair indication of resource (FTE) needs and system health, as typical emergency-type work is unscheduled and often times either starts and/or ends during typical non-working hours (overtime). It is worth noting that weather as well as other non-maintenance-related emergencies are also captured in this metric such as the Carr Fire in Sierra Nevada that burned in Shasta and Trinity counties in California, which resulted in a spike in overtime for maintenance crews to respond to system needs.

Color Legend / Regions:

- RM
- DSW
- SN
- UGP
- WAPA

Reactive, Corrective and Emergency Maintenance Costs



Commentary:

The total expenditures on reactive, corrective and emergency work across WAPA's power system for January 2017 through November 2018 reached \$32.2M, with 77.4% (\$24.9M) performed on transmission lines. The top three equipment classes with the most maintenance costs outside of planned maintenance are transformers, circuit breakers and transmission lines.



DATA COMMUNICATION

AM must effectively communicate data to stakeholders who use the information to inform their business and capital planning decisions. To ensure strategic communication, an Asset Management Communication Plan is used. This plan identifies all stakeholder groups and assigns roles and responsibilities for executing key communication 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
- HQ Asset Management specialists
- Regional capital planning groups

EXTERNAL

- Regional customer groups
- Customer representatives
- North American Transmission Forum
- Electric Power Research Institute
- Regional capital planning groups
- Technical committees
- Engineering and operating committees

DATA VALIDATION

Accurate and current asset management data is important to achieve the confidence required by stakeholders. Validating data is carried out in two ways: qualitatively and quantitatively.

- Incorrect data and missing data reports are prepared monthly to identify gaps in asset data that may be driving incorrect asset health or risk scores
- Asset management data is validated with knowledgeable field crews to ensure asset scoring is representative of true field conditions

ASSET MANAGEMENT OBJECTIVES

NEAR TERM

- Strategically add asset classes to the AM portfolio in support of regional capital investment needs
- Communicate asset management data analyses to stakeholders
- Create more intuitive and informational displays to share asset management data
- Gain better understanding of the causes of planned reactive, unplanned corrective and emergency maintenance that is occurring between preventative maintenance cycles

LONG TERM

- Integrate asset health for condition-based maintenance activities
- Streamline 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



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