

Transmission Overarching Sustain Strategy FY2017-2030

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Executive Summary

Transmission Capital Program

With BPA's responsibility to serve the majority of the Northwest region's high voltage needs, a robust asset management strategy and plan for deployment for capital is essential. The strategy covers nine primary asset programs including alternating current substations, direct current substations, control centers, power system control, system telecommunications, system protection control, rights-of-way, wood pole lines and steel lines. The assets within these programs deliver electric power to more than 12 million people through four product categories:

- Transmission service to regional utilities and to commercial, industrial and other loads.
- Generation and line and load interconnections.
- Interregional transfers of capacity and energy.
- Ancillary services, such as regulation and load following services.

Vision & Long Term Goals

The vision for managing transmission assets at BPA states "Transmission Services will manage its assets to achieve high reliability, availability and adequacy standards and maximize economic value for the region. It will use efficient and transparent practices that are effective in managing risks and delivering results." With this vision, long-term Transmission asset management goals have been developed that focus on:

- Conforming to leading asset management practices based on the ISO 55000 series.
- Integrating system expansion, replacements and maintenance to optimize the asset lifecycle.
- Prioritizing investments in terms of asset criticality and risk to meet reliability and other standards at lowest total economic cost.
- Delivering on the asset management strategy through a balanced funding and resourcing plan.
- High data quality for asset attributes, e.g., condition and performance to support decision-making.

Aligning to BPA's Priorities, Key Strategic Initiatives and Focus 2028

The transmission asset management strategy aligns with BPA's priorities for Physical Assets, Sustainable Finances & Rates, and Reliable, Efficient and Flexible Operations. Action plans for Focus 2028 are taking shape and will support the implementation of BPA's Key Strategic Initiatives for Asset Management, Long-Term Financial & Rates and Business Information Systems.

The landscape of the utility industry is in the midst of great change, resulting in an increased need for flexible products and services to maintain a competitive position and effectively serve the Northwest. BPA must position itself to adapt as forecast demand, impacts to energy markets, generation choices, and national, regional and local policies evolve. In November 2015, BPA launched Focus 2028 with customers and regional constituents to begin a dialogue about the changing environment, focusing on the future and opportunities to enhance the value provided to the region. Transmission Services is developing action plans for managing the transmission system today through well-planned, cost effective asset plans, while also positioning Transmission to meet the regional needs of tomorrow.

Transmission Services' Strategic Priorities

Transmission Services is currently in the early stage of implementing several major strategic priorities in the areas of System Infrastructure, System Operations and Commercial Success. These priorities must be addressed in the context of achieving the fourth priority, System Reliability Compliance. The fifth

priority, Information Technology / Operations Technology, integrates information and operations technology across the other four priorities.

Challenges

Today's utility environment has exerted additional demands on how BPA's transmission assets are managed. The transmission asset management strategy must manage the following challenges:

- Address backlogs in sustain investments and deferred maintenance.
- Ensure reliability and interoperability of equipment, and avoid technological obsolescence.
- Make health condition data accurate, available and useful to prioritize critical work.
- Balance customer demand with outages to execute maintenance and replacement projects.
- Respond to evolving and increasing regulatory and compliance requirements.
- Address increasing physical and cyber hazards that put the transmission system at risk.
- Ensure transmission operators have greater system visibility, more accurate models, and enhanced automated controls to maintain reliability.

Strategic Approach

For replacing existing assets, Transmission's key sustain programs utilize total economic cost (TEC), as its primary driver to determine asset strategies, replacement plans and efficiency improvements. TEC quantifies risk in terms of all failure probabilities leading to outages and line derates and aggregates associated cost. TEC results are collectively analyzed across sustain programs to prioritize replacements based on optimal funding levels to minimize total economic cost. Four major TEC strategies have been developed for substations, lines and rights-of-way, system and protection control (SPC) and power system control (PSC) / system telecommunication, and control centers.

Efficiency Improvements

Vital efficiency improvements were identified during strategy development that add value to the system and help reduce total economic costs. Some progress has been made, but full implementation of all improvements relies on adequate expense funding. Examples of efficiency improvements are:

- Pre-deployment testing, training and documentation for Power System Control
- Predictive analysis using cameras, sensors and monitors in substations
- Circuit breaker and transformer Electric Power Research Institute (EPRI) asset management tools to provide advanced analytics on maintenance and reliability
- Line condition data analysis and gap identification to create a data collection structure
- Maintenance expense pilot for access roads and an engineering-driven expense pilot for lines

The *Asset Management and Program Delivery (AMPD)* initiative is the primary driver for Transmission Service's System Infrastructure strategic priority, which is a major element for the asset strategy.

Specific efficiency improvements to facilitate reaching this objective are:

- Implementing technology enablers, such as creating portfolio management tools and enhancing the asset register for greater accessibility and visibility of higher quality asset data.
- The creation of the Project Definition Team (PDT) in FY 2016 to enable more robust project scoping and stage gates, adding certainty to project cost and delivery
- Establishing a portfolio management function to centrally manage and optimize the portfolio
- Effectively manage change for all process improvements within the various impacted organizations

Performance Measures

Transmission Services has adopted key performance measures and targets to monitor the overall reliability, adequacy and availability of BPA's transmission system.

- Excursion Minutes over System Operating Limits (SOL): Minutes of actual path flow over SOL are to remain within targeted limits.
- System Operations Reliability: No involuntary curtailments of firm load, system security breaches, or cascading outages originating on the BPA system.
- Unplanned Outage Frequency and Duration (Pilot): Provides an indication of BPA's success at minimizing the frequency and duration of unplanned transmission line outages.
- Optimal Path Usage: The percentage of time that actual flows (MW) on key paths is to remain within targeted levels.
- Asset Management Key Performance Indicator: Execute implementation plans for strategic priorities and enable the organization to more efficiently and effectively do the work.

Capital Levels

Transmission Services' asset strategies recognize an optimal level of capital toward best mitigating risk and reducing total economic costs. Each sustain program's strategy identifies an optimal level of funding to reach steady state for high value critical replacements within the next 15-20 years. However, in an effort to minimize regional impact, BPA is proposing a lower base level of capital that will result in a manageable rate increase for BP-18. It is expected that the base funding will still address system needs, however at a delayed pace from what the asset strategies require. Base capital levels for FY 2017-2019 are predicated on FY 2014 CIR levels, averaging to \$218M per year. These base levels are ~\$230M less than the optimized levels from the strategy, which is approximately one year of sustain work. The FY 2020-2030 base levels attempt to ramp back to alignment with the optimal strategy levels, averaging \$312M per year.

Risks to Implementing the Strategy

By funding at the lower base levels in the near term, reaching a steady state for high value critical replacements in the next 15-20 years is at risk. As a result, corrective maintenance costs will increase and the backlog will continue to grow. AC substations, one of the most critical programs identified from the total economic cost strategies, is currently working to address a ~\$800M backlog of equipment beyond its expected lifecycle. Based on the near-term funding trajectory of the sustain capital budget, 10-20% of the sustain capital budget is projected to address emergencies and unplanned work, per an assessment conducted by the Strategic Decisions Group (SDG) in October 2015. Increases in fiber outages also pose a risk to the system. In FY 2015, BPA experienced 30 fiber outages as compared to an average of 10 per year from 1999-2009. Analysis has shown 40 fiber outages per year means it is almost certain that BPA will experience transmission curtailments. Curtailments would result in a reduction of load that can be served and reduction of generation allowed on the system; both of which would reduce revenues and damage reputation. In addition, Transmission Services' faces enterprise risks in regards to its workforce for resources and talent adequacy, as well as increasing regulatory compliance and a changing industry landscape.

The base levels put BPA's ability to achieve the benefits of the optimized program asset strategies at risk. Both the critical high value replacements and the efficiency improvements require capital and expense funding represented in the optimized levels to execute the strategy at the right time, at the right cost, to maintain reliable transmission service to the region.

1.0 Background

Profile of assets

BPA owns and manages about three-fourths of the Northwest region's high voltage transmission assets. This system spans approximately 300,000 square miles and includes more than 15,000 circuit miles of transmission lines and approximately 300 substations. These assets deliver electric power, directly or indirectly, to a population of more than 12 million through four product categories.

- Transmission service to regional utilities and to commercial, industrial and other loads
- Generation and line and load interconnections
- Interregional transfers of capacity and energy
- Ancillary services, such as regulation and load following services

Assets covered by this strategy:

Alternating Current Substations: 261 Substations and ~32,000 major equipment categories

Power Transformers and Reactors, Power Circuit Breakers, Circuit Switchers, DC Control Batteries and Chargers, Shunt Capacitors, Current Limiting Reactors, Instrument Transformers, Engine Generators, Surge Arresters, Fuses, Disconnect Switches, Rigid Riser Replacement, Substation Grounding, Substation Bus and Structures, Low Voltage Station Auxiliary, Control Houses

Direct Current Substations: Celilo Converter Station

HVDC Converter Station, Static Var Compensators, Fixed Series Capacitor Banks, Thyristor Controlled Series Capacitor Banks

Control Center: 2 Control Centers with 85 plus automation systems

Real-time grid control and management systems; grid and data center monitoring, protection, and alarm systems; CC critical power infrastructure; non-real-time operations analysis and support systems; commercial business systems/facilities integration and support

Power System Control / Telecommunications: 732 sites and ~11,000 pieces of equipment, 3,000 miles of fiber optic cable

RAS, Transfer Trip, SCADA remote terminal units, Fiber cable, Comm batteries/chargers, SONET/MW Radios, VHF/mobile/portable radios, UHF, DATS, Multiplex, Power Line Carrier, Telemetry, Operational Networks and their management, Engine Generators, Supervisory Control Systems, UPS, Telephone systems, Telephone protection, Field Information Network, Misc support systems

System Protection and Control: 956 locations, ~28,000 pieces of equipment, 33 equipment types

Transformer relays, Bus relays, Line relays, Breaker relays, RAS, Reactive relays, Revenue metering and Control, SER, DFR, Control equip, Load shedding relay, Indicating Meter Transducers, Relay Communications

Rights-of-Way: 195,600 acres of BPA maintained ROW corridors, 319 corridors, 423 transmission lines, 368 communication sites, approx. 11,860 miles of access roads, approx. 80,000 tracts of easement

Access roads, Roads, Bridges, Culverts, Trails and gates, Tracts of easement

Wood Lines: Approx. 4,800 miles, 336 separate transmission lines with 73,500 wood poles

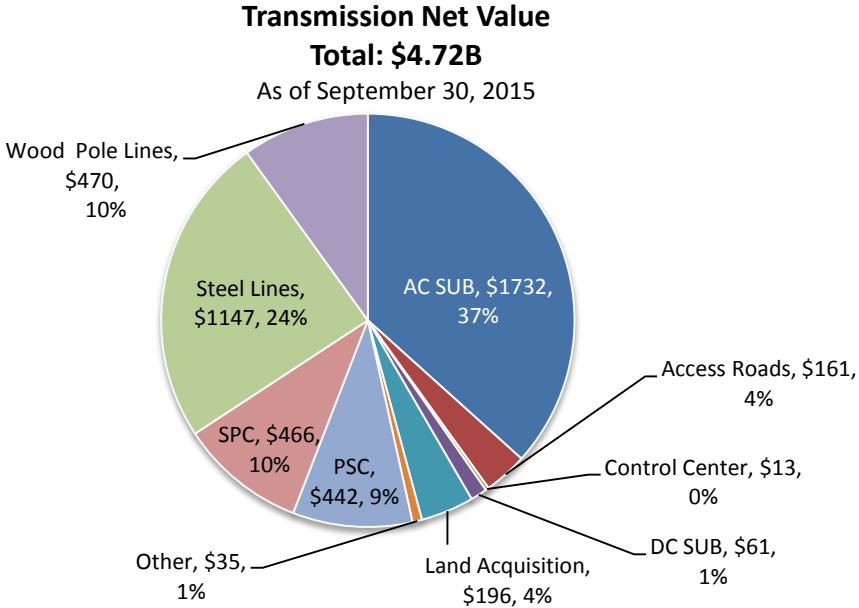
Poles, Conductors, Insulator assemblies, Guy assemblies, Fiber optic cable, Line disconnect switches, Ground wire, Counterpoise

Steel Lines: 10,300 circuit miles with 43,500 lattice steel and engineered steel pole transmission lines and all associated towers, hardware and components

Towers, Connectors, Conductors, Insulator assemblies, Footings, Dampers, Counterpoise

Since 2008, Transmission Services has been maturing its asset management program with a goal of sustaining its existing assets at optimal lifecycle cost. Sustainment planning accounts for the condition of the assets and the demands placed on them. The strategy provides the direction for addressing the most critical assets first, while a corresponding plan has been developed to mitigate risks of equipment failure, obsolescence and replacement backlogs at lowest total economic cost. Total economic cost is the sustain program’s standardized and integrated method for quantifying risk, accounting for the health condition of equipment, the likelihood of equipment failure and the potential for curtailments and outages should equipment failure occur.

Transmission Services also funds capital investments in information technology, environmental work, nonelectric facilities, fleet, aircraft, and security enhancements in support of the transmission program. These investments are addressed in separate asset strategies for these asset types due to the unique drivers behind the investments.



Business Environment

Strategic Landscape

For many years BPA has responded to various market dynamics from a relatively tactical perspective, making investment decisions to address urgent and increasing pressures from multiple facets of the energy industry. Mandatory reliability standards and other compliance directives, shifting regional needs and resources, changing generation patterns, renewable energy growth, rapidly growing load sectors such as data centers, and evolving technologies are just some examples of external factors that have created a complex web of requirements for Transmission Services. To make matters more complicated, BPA must balance external factors with internal factors – financial constraints are tightening, technical experts are retiring, stakeholder and performance expectations are increasing and system infrastructure continues to age. Taking a step back to assess investments within a more holistic framework that accounts for long-term cost implications and highest value to the system is more important than ever.

Focus 2028

In November 2015, BPA initiated Focus 2028, a forum for regional leaders to begin establishing a common understanding of the types of industry changes and strategic choices BPA may face to maintain its financial strength and cost competitiveness. BPA is focused on being positioned as the low-cost energy provider of choice when new power sales contracts are offered by 2028. This means adapting to changes in forecasted demand, impacts to energy markets, generation choices and national/regional/local policies. Topics of discussion include the effects of the California Independent System Operator's (CAISO) Energy Imbalance Market (EIM), which could result in dispatch changes; increasing Renewable Portfolio Standards (RPS) requirements adding pressure for more wind investments with 9,000 MW of transmission service requests in the queue already; and rapidly evolving energy storage technology and utility-scale development interest.

BPA Transmission Services' strategic approach to Focus 2028 is to operate and maintain the Transmission business of today with an emphasis on cost management, strategic prioritization choices, evaluation of alternatives to expansion, investing to save, and seeking efficiencies through operational excellence to position Transmission to meet tomorrow's regional customer needs. Action plans are being developed under this approach and are supported and aligned with asset plans to poise BPA and its customers to proactively address and benefit from market forces and factors.

Long-Term Financial and Rates Analysis

Many variables could impact BPA's long-term cost structure, which in turn, could adversely impact BPA's long-term competitiveness. In order to analyze the impact of near term decisions on future rates, the Long-Term Financial and Rates Analysis capability was created. This 15-year analysis of BPA's financial condition and rates is comprised of capital and expense spending levels presented in various scenarios based on a variety of assumptions. In Transmission Services, several scenarios were created to show rate impacts of spending levels for the status quo (BP16 levels), optimized system needs based on total economic cost, and modified system needs with some constraints applied. To keep rates manageable in the short-term for BP-18, Transmission Services is proposing capital spending levels that are in line with BP-16 levels. The Long Term Financial and Rates Analysis is intended to serve as a reference case to begin strategic discussions and also will be used as the basis for comparing the financial and rate implications of future scenarios.

Recent Accomplishments

Sustain Program Replacements

In FY2014 and FY2015, the sustain program was successful in replacing capital assets at higher than historical levels. Notably, in FY2014 the control center, communications and substations sustain programs executed at the highest levels since the sustain program's inception in FY2008. Even with this progress, there is still a substantial backlog of replacements. Some examples of the work accomplished are below:

- 7 grid operations system assets were replaced in FY2014 as compared to 2 grid system operations assets in FY2014 for the Control Center program
- 120 relays were replaced in FY2014 as compared to 38 relays in FY2010; relays are considered the most critical asset in the system protection and control (SPC) program
- 30 transfer trips were replaced in FY2014 as compared to 4 transfer trips in FY2010; transfer trips are considered the most critical asset in the power system control (PSC) program

- 60 circuit breakers and other switchgear elements were replaced in FY2014 as compared to 27 in FY2010; circuit breakers and switchgear are considered very critical assets to the Alternating Current Substations (AC SUB) program

Transmission Asset Strategy Integration

The Transmission Asset Strategy Integration (TASI) initiative completed in FY2016 after six years of development, resulting in a cohesive asset strategy that focuses on reducing total economic cost as the common and standardized approach across sustain programs. Strategies have been developed and integrated across PSC, SPC, Substations, Vegetation Management, Access Roads, Wood Pole Lines, Steel Lines and Control Center programs, for a total of four strategies:

- Active Coordination strategy – PSC/System Telecommunications and SPC
- Hybrid strategy – Substations
- Integrated Data Driven (IDD) strategy – Vegetation Management, Access Roads, Wood Pole Lines and Steel Lines
- Evolved Service Focus strategy – Control Center

These strategies comprise the foundation of the sustain program’s asset management strategy and focus on replacement plans, but also require high value efficiency improvements to fully realize strategy benefits. They are further supported with replacement plan modeling capabilities that can be aggregated together through a sustain portfolio tool. The sustain portfolio tool combines each program’s replacement plan and calculates total economic cost impacts based on various funding levels. More details on the strategies are provided in the strategic approach section of this document.

Efficiency Improvements

As part of the TASI assessment, a series of efficiency improvements were recommended to maximize value and reduce total economic costs. Several of these improvements have been implemented in the past few years and are further detailed below.

- The PSC training room was built in FY2014 and is being used to train 21 PSC craftsmen that were hired in FY2015. While the original recommendation proposed hiring more training resources, PSC is using existing resources due to funding constraints and has subsequently experienced improvements in craftsmen work quality.
- A communications testing facility was built in FY2014 to conduct testing prior to deployment with the purpose of preventing rework during installation. PSC is using the testing facility and seeing benefits by catching equipment issues in the facility instead of in the field with the idea of “test twice, install once.”
- The Access Road Maintenance Pilot has been established to improve contracting mechanisms for environmental clearance and expense construction. It will help prioritize access road expense work and provide transparency to field districts.
- The AC substation program has worked with EPRI to develop cutting-edge advanced analytical tools. The Power Transformer Expert (PTX) tool, EPRI Industry Wide Database (IDB) and Circuit Breaker Replacement Ranking (CBRR) tools help identify the effective age of transformer and circuit breaker equipment based on asset performance and the resulting analytics help provide data to make replacement and maintenance decisions based on total economic cost.

The AMPD initiative is focused on implementing a series of improvements that will provide better certainty in the planning and execution of Transmission Services’ capital portfolio. In FY2016, the AMPD team developed a revised capital project process that identifies all key activities and relationships within the capital program and identified capabilities to improve delivery. AMPD has also developed new

processes to bring engineering into the planning process earlier to improve scoping and put in stage gate controls for authorization of funding. These processes will better define the investment up front to prevent cost and schedule overruns, rework and duplicative efforts.

Transmission Insurance Project

Reliable, efficient and flexible operations are a priority for BPA, and the ability to plan for and react to unplanned, catastrophic events is critical. BPA has recently taken steps to insure over \$8 billion in transmission assets in terms of replacement value. The policy took effect October 31, 2015 and is collectively covered by 13 carriers, whom were all impressed with BPA's seismic hardening efforts. It covers substations, Dittmer and Munro control centers and critical facilities like the Ross Complex and Celilo Converter station. It does not cover transmission lines, poles or towers. The property insurance will benefit BPA and ratepayers by providing more predictable financial protection, insuring previously unprotected assets, providing a source of short-term capital in the event of a claim, and allowing more rate stability and protection from significant financial risks of earthquake, cybersecurity and terrorism events.

Transmission Asset Portfolio Management Tool

The Transmission Asset Portfolio Management (TAPM) tool started as a pilot back in FY2014 to consolidate three legacy systems into one with the primary purpose of housing and maturing the 15-year transmission asset plan. Three releases of improvements were implemented based on changes selected by the TAPM User Group through an iterative, agile software development lifecycle process. TAPM has made the asset plan visible to users across Transmission and broken down several system silos and spreadsheets. It integrates with multiple systems including the business case library for investments, the estimating system and financial reporting data in execution.

Asset Register Progress

- The Transmission Asset System has recently been enhanced by incorporating line assets into Cascade, the computerized maintenance management system, in addition to substation and communications assets. The user interface uses a geographical information system (GIS) to navigate line assets for AC SUB, SPC and PSC. This GIS interface improved the lineman user experience and assured successful adoption. In FY2016, Cascade began collecting asset condition data and managing compliance for lines assets.
- A standardized process for requesting changes to the assets or to the TAS system is in place to facilitate monitoring and categorizing the requests for asset changes, prioritization, resource assignments, and day-to-day work progress. The asset register request backlog went from 3000 to 300 requests since the initial stand up of the ADM organization in December 2013. In FY2016 the focus is on the 300 remaining/active requests that are managed through the Cascade Configuration Team (CCT) and associated processes

Benchmarking

In early FY2016, Transmission Services' conducted several benchmarking workshops with Tennessee Valley Authority (TVA), a peer federal energy agency to compare asset management practices. Topics included business context and environment, compliance, asset management strategy, financials, performance management and asset planning. Both agencies learned about each other's various approaches to asset management and provided insight into respective issues.

2.0 Objectives of this strategy

The Transmission Asset Management Strategy provides the roadmap for managing the health, performance, costs and risks of transmission assets owned or leased by BPA. This is achieved through the sustainment of critical assets to meet reliability and availability requirements.

Vision for managing transmission assets

Transmission Services will manage its assets to achieve high reliability, availability and adequacy standards and maximize economic value for the region. It will use efficient and transparent practices that are effective in managing risks and delivering results.

Long-term goals

- Conforming to leading asset management practices based on the ISO 55000 series
- Integrating system expansion, replacements and maintenance to optimize the asset lifecycle
- Prioritizing investments in terms of asset criticality and risk to meet reliability and other standards at lowest total economic cost
- Delivering on the asset management strategy through a balanced funding and resourcing plan
- High quality asset information attributes, e.g., condition and performance to support decision- making

Transmission Strategic Priorities

System Infrastructure – Assets and Technology

Asset management quality and systems are substantially advanced. Robust project integration, and implemented technology strategy and governance, together preserve and enhance the reliability and availability of the existing and future transmission system infrastructure.

System Operations – Stability and Future Flexibility

System reliability is preserved and enhanced, confidence in firm transmission delivery is increased, confidence in optimized available transfer capability (ATC) is increased, and abilities to proactively manage congestion and system events are improved. This is based on a platform of integrated analytical capabilities that advance operational planning, outage flexibility, system management, and alignment between system operations and internal and external parties.

Commercial Business Success – Responsive, compliant, market-based Transmission products

The fiscal foundation that enables Transmission to provide products and services and market-based system expansion projects that satisfy customer’s evolving needs is strengthened. Cost effective alternatives to expansion are rigorously evaluated and implemented when equivalent system reliability can be ensured. Transmission products respond to the changing industry marketplace, consistent with BPA statutes and regulatory requirements. Transmission Services provide flexible, innovative, timely, compliant, cost-effective and desirable products and services that are well-coordinated and executable.

System Reliability Compliance – Proactive engagement, improved reliability grid

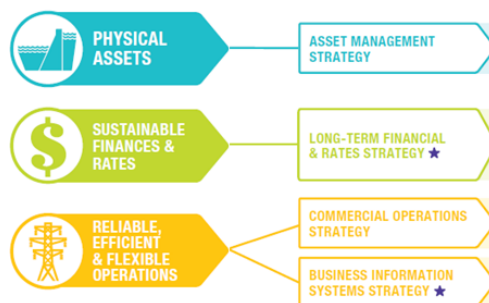
System Reliability Compliance is recognized and valued agency-wide as a critical element of BPA’s competence to improve grid reliability performance in the Pacific Northwest, so that BPA has zero repeat violations. In cooperation with WECC, BPA employs a risk-based methodology and applies resources where the greatest reliability benefit may be achieved.

Information Technology – Timely technological solutions supporting strategy implementation

Both information technology capabilities and enabling technologies are in place and functioning when required to support the four other strategy efforts.

Alignment to BPA’s Priorities & Key Strategic Initiatives

The transmission asset management strategy aligns with BPA’s priorities for *Physical Assets*, *Sustainable Finances & Rates*, and *Reliable, Efficient and Flexible Operations*. Improvement activities implement these priorities through a set of BPA-wide Key Strategic Initiatives (KSI): *Asset Management*, *Long-Term Financial & Rates* and *Business Information Systems*. Action plans for Focus 2028 are taking shape that will align with the implementation of BPA’s KSIs and the efficiency improvements currently underway from Transmission Services’ strategic priorities.

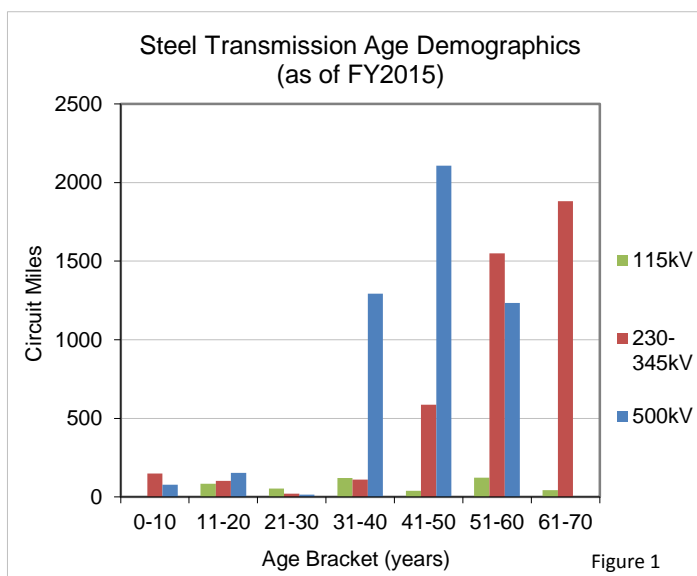


3.0 Strategic challenges

BPA is nearly 80 years old and more than 50% of its transmission facilities were constructed prior to 1962. The system is a complex network of transmission assets with varying vintages, conditions and capacities to address a wide array of system needs. Changes in generation patterns and loads bring new demands. This has presented strategic challenges pertaining directly to the assets, such as aging infrastructure, investment backlogs, and technological obsolescence. It has also presented strategic challenges on how BPA manages the assets, such as prioritizing and managing the capital replacement portfolio, having quality asset information to make decisions, as well as having the appropriate resources and knowledge to replace and maintain the assets.

Aging Infrastructure

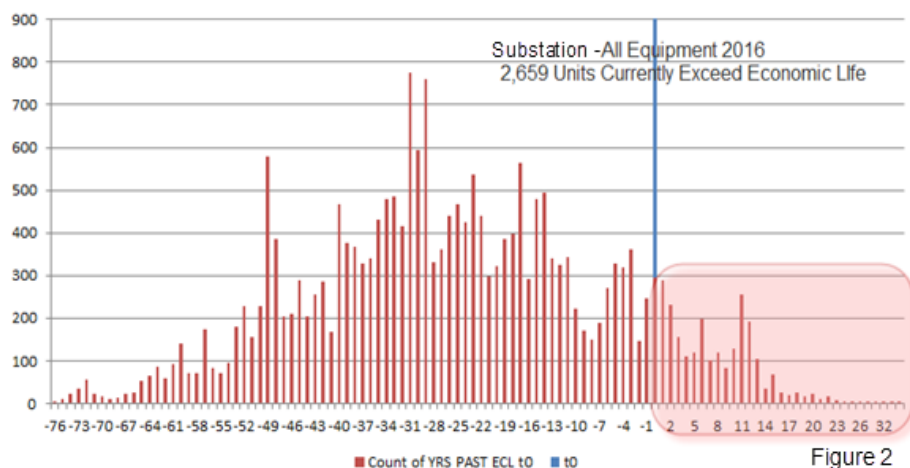
Transmission assets generally have long expected lives. On BPA’s system, it’s not unusual to encounter transformers, structures or other components that are over 60 years old. Over the years, long asset lives have enabled BPA to push replacements farther into the future. This provided BPA with flexibility to address expansion needs, budget and rate pressures, and unplanned contingencies. However, persistent delay of investment has resulted in a substantial backlog of replacement needs, higher maintenance expense and higher risk of equipment failure and obsolescence. To illustrate, Figure 1 indicates that an estimated 60% of steel line components are approaching theoretical end-of-life, with 50 years as the average service life.



Operating equipment beyond its expected service life increases the likelihood of failures with accompanying outages and emergency response costs. In the period from 2005 through September 2015, BPA experienced 24 outages in excess of 240 minutes that were mainly due to material failure.

Replacement Backlog

Another challenge is the growing replacement backlog, which is the volume of equipment determined to be past its optimal life cycle. BPA's substations had a backlog of approximately 2,400 pieces of equipment in FY2014 and it has increased to 2,659 pieces of equipment in FY2016, as shown in Figure 2 in the red box. The blue line is a "you are here" marker in FY2016 with work to the left of the line showing the volume of assets that will need to be replaced in the future based on the number of remaining effective life years. Minimizing the backlog is paramount for the asset management program to reach a steady state of replacement, where the future replacement walls are smoothed and manageable to reduce economic cost. The growing backlog will lead to a higher probability of failures that could potentially cause unplanned customer outages with regional implications. Many existing assets are also not designed or constructed to withstand potential operational, physical, cyber and natural disaster threats.



Technological Obsolescence

Transmission Services is faced with rapidly evolving technology in several different programs such as system telecommunications, system protection and control, and control centers. BPA has generally lagged behind the industry and is feeling the effects of this delay. Maintaining system and equipment operability with multiple older vintages of equipment has increased the inventory of equipment needed for spare parts, creates additional instances of equipment failure, and increases the risk of system misoperations. Maintenance and inventory costs have increased as a result. While some equipment may still be in fair or good condition, the lack of vendor support and replacement parts makes repairs very expensive, requiring custom machining and testing of replacement components and increases the potential for outages of unacceptable duration. Given resource and execution constraints, transitioning from analog to digital radios within the next five years has slowed, as well as the progress for transitioning critical electro-mechanical and electronic relays to microprocessor relays within the next 10 years.

In addition, there are many new technologies that would provide Transmission Services with flexibility on the system for performing replacements and O&M activities without requiring an outage. Transmission Services is focused on identifying and implementing technologies that would reduce the number and the duration time of outages for maintenance, repair and replacement. Transmission Services is partnering with Electric Power Research Institute (EPRI) and other utilities to develop a technology research and development roadmap.

Capital Portfolio Management

Compliance with mandatory reliability standards, safety improvements and policy-driven investments constituted approximately 45% of FY2016 capital sustain work in addition to purely system reliability-driven replacements. Contending with those mandated investments in addition to other competing priorities requires robust capital portfolio management to ensure high value critical replacements are installed. Prioritizing, executing and managing the capital portfolio to deliver the right work, at the right time, at the right cost continues to be a challenge in a budget and resource constrained environment. The Asset Management and Program Delivery (AMPD) initiative, launched from Transmission's System Infrastructure priority, is addressing issues and gaps in capital portfolio management, which are detailed in the Process and Program Improvements section.

Resource Constraints

A large part of Transmission Services' workforce is comprised of engineering and analytical experts that have long careers at BPA and understand the complex nature of the transmission system and its requirements. In many cases, the deep knowledge of how to keep the business and system running resides in their minds and is not documented well and/or has not been transitioned to a successor. The workforce is aging and approximately 1/3 of BPA employees are eligible to retire by FY2019. This has presented a challenging resource constraint in terms of firming up bench strength to carry out mission essential functions for Transmission Services. These issues will be addressed at the Agency level through the Workforce Strategy key strategic initiative. In addition to the top enterprise risk of an aging workforce, there are strategic resourcing issues to find skilled workers to perform transmission work. Looking externally to contract work has been difficult due to lack of available bidders and cost premiums.

Asset Information

Transmission Services' asset register, known as the Transmission Asset System (TAS), is foundational to the Transmission asset management program because it provides the data and information necessary to prioritize its maintenance and replacement programs. While TAS is in place, there are still many gaps, as well as many disparate systems outside of it that are not integrated. During the past few years, Transmission Services has focused on defining the requirements and refining processes to support data gathering and analysis. The Asset Data Management (ADM) organization was created in FY2013 to develop, manage, and drive continued improvement in support of this effort. Since its inception, the ADM group has been evaluating the completeness and accuracy of the asset data that is stored in TAS. Multiple internal assessments have been performed to understand the accuracy of current asset data.

In FY2015, the Asset Information Project (AIP) under the AMPD initiative was launched to develop a Transmission *asset information strategy* as defined by the Institute of Asset Management. The project will identify and prioritize efforts to close key gaps in transmission asset data, information and systems. A roadmap for implementation of the asset information strategy is expected by end of FY2016. This effort is linked to the Asset Management KSI and the Business Information System KSI to support BPA's priorities.

4.0 Major elements of the strategy

Strategic approach

Total economic cost

The backlog of underinvestment in the sustain program makes it imperative for the Transmission Asset Management Strategy to incorporate a solid approach for prioritizing its resources toward mitigating the most critical risks. Transmission Services recently completed the Transmission Asset Strategy Integration (TASI) initiative, which evaluated all sustain program strategic alternatives on the basis of reducing *total economic cost*. This leading-practice involves assessing the health condition of equipment, the likelihood of equipment failure and the potential for curtailments and outages should equipment failure occur, and is the heart of the sustain asset strategy. This method produces a risk-informed prioritized program of asset replacements and internal efficiency improvements designed to minimize BPA costs and customer value losses from equipment failures over time. A value map for what constitutes total economic cost is shown in Figure 3.

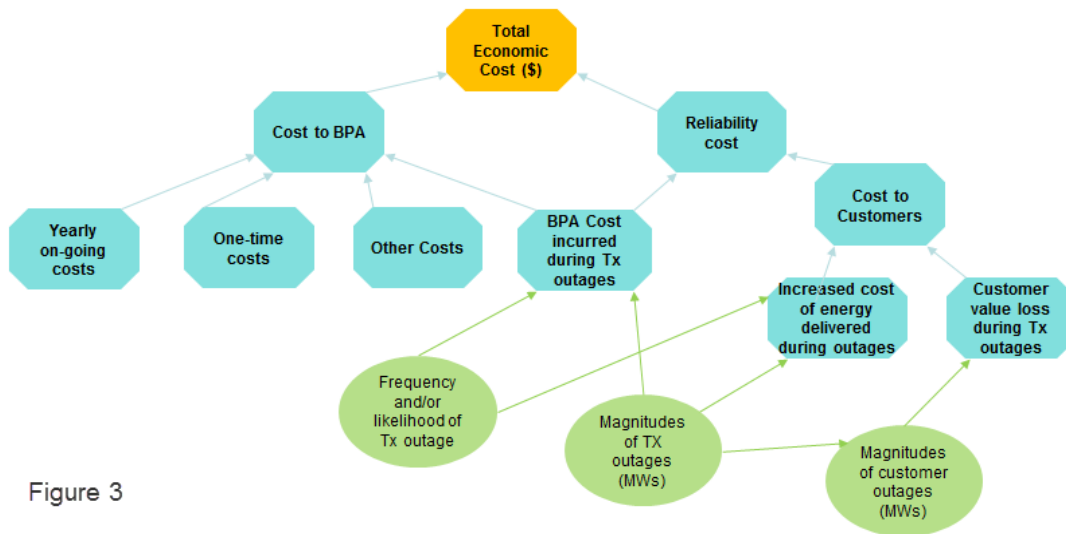


Figure 3

Strategy development process

Each total economic cost strategy underwent the same development process where key subject matter experts were used to assess and frame the situation, develop value maps, gather information, create total economic cost quantification models, evaluate and create strategy alternatives, identify challenges and likelihood of success and then make a final strategy recommendation. Upon strategy selection and approval, detailed implementation planning was initiated to execute the strategy.

Total economic cost strategy elements

Both the replacement plans and efficiency improvements are required for successful execution of the strategies in minimizing total economic cost.

Total economic cost informed replacement plans

- Economic lifecycle replacement balances ongoing cost with system reliability risk and cost
- Addressing the backlog of equipment beyond its economic lifecycle reduces reliability risk and associated costs

Reducing total economic cost through efficiency improvements

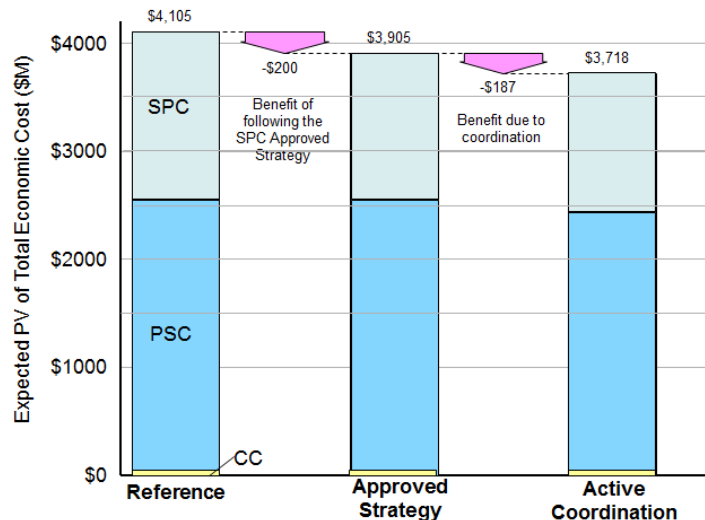
- Equipment inventory and asset condition data collection and analysis enables economic replacements and repairs and avoiding outages
- Documentation and training increases the FTE efficiency and reduces rework

- Pre-deployment testing ensures in-field compatibility of new technologies
- Economic bundling and coordination of work across assets reduces costs and maximizes the utilization of planned outages

Transmission Sustain Strategies

PSC & SPC – Active Coordination Strategy

In FY2011, SPC and PSC/System Telecommunications programs came together to determine a total economic cost based SPC and PSC/System Telecommunications strategy. After considering various strategy alternatives, the Active Coordination strategy was selected. Compared to the previous strategy (Reference), Active Coordination reduces total economic cost by \$387M over a 30 year horizon.



Main attributes of this strategy

- Replacements are based on the equipment economic lifecycle (i.e. based on impact to the total economic cost)
- Disciplined process for coordination of planning, planned outages and execution is developed
- Improved training, pre-deployment testing and documentation is available
- A formalized council between SPC, PSC/System Telecommunications and Control Center that covers all equipment from those respective programs and coordinates current and new technologies is established
- A robust staffing strategy is created to support needed replacements

Steady State – Success Vision

Through a situation assessment with key stakeholders, success has been defined as:

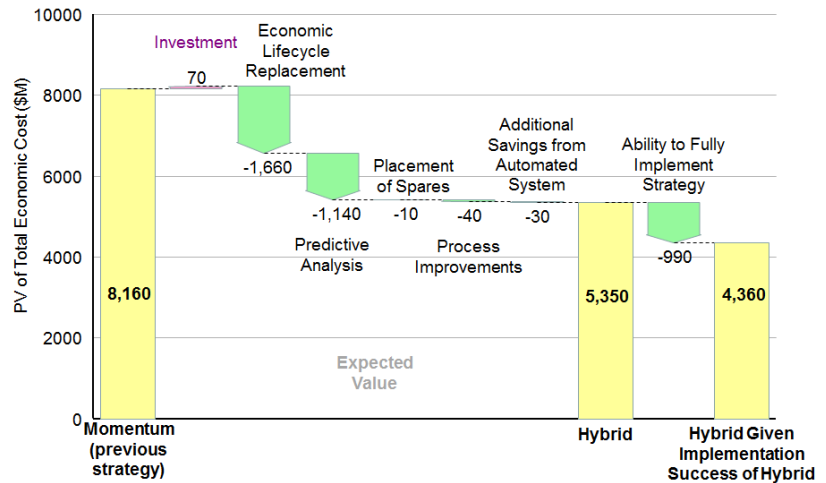
- Incremental progress between SPC and PSC/System Telecommunications coordination
- Less rework in the field as a result of improved training, testing and documentation
- New technologies are assessed and incorporated
- Successful implementation of total economic cost driven replacement plans as a result of appropriate staffing

Efficiency Improvements

- Formulate a council across SPC, PSC/System Telecommunications and Control Center programs to coordinate current and future technologies
- Improve documentation, training and pre-deployment testing to prevent rework
- Add targeted spares kits for PSC/System Telecommunications in high impact areas
- Collect SPC inventory data to better inform replacement plan

Substations – Hybrid Strategy

In FY2013, various substation subject matter experts came together to determine a total economic cost based substations strategy. After considering various strategy alternatives, the Hybrid strategy was selected. Compared to the previous strategy (Momentum), Hybrid reduces total economic cost by \$3.8B over a 45 year horizon.



Main attributes of this strategy

- Replacements are based on the equipment economic lifecycle and addressing backlogs
- Information is utilized from relays, sensors and cameras to conduct predictive analysis
- Maintenance is shifted from time-based to condition-based
- Outages are coordinated bay-to-bay across assets
- On-site spares are adequate and have improved placement
- Contractors are pre-qualified, certified and trained, so they are available and ready to work, meeting BPA standards

Steady State – Success Vision

Through a situation assessment with key stakeholders, success has been defined as:

- Stable and constant system reliability where most work is anticipated, accrual to the backlog is limited and 5-year plans are accurate and robust through executing work based on economic lifecycle replacement
- Funding, resources and planned outages are not constraints through bay-to-bay coordination and contractor pre-certification
- Information and the right diagnostic tools necessary for replacements and maintenance are available through predictive analysis and spares additions

Efficiency Improvements

- Transformer asset management tool to determine projected transformer reliability and need for additional diagnostics
- Circuit breaker asset maintenance tool pilot to shift from time-based maintenance to condition-based maintenance
- Predictive analysis using relay, cameras and sensors in substations through a phased pilot approach to better inform replacement and maintenance intervals

Lines & ROW – Integrated Data Driven+ Strategy

In FY2014, the Vegetation Management, Access Roads, Wood Pole Lines and Steel Lines programs came together to determine an integrated Lines and Rights-of-Way strategy. After considering various strategy alternatives, the Integrated Data Driven (IDD) strategy was selected. Compared to the previous strategy, IDD+ reduces total economic cost by \$1.2B over a 200 year timeframe, given the long life of line assets.

Main attributes of this strategy

- Replacements are based on economic lifecycle and effective age in order to reduce total economic cost
- Work is bundled based on economic lifecycle and effective age in order to create labor and planned outage efficiencies
- Repair backlog is addressed aggressively in order to reduce the long term backlog of equipment requiring corrective work
- Data collection structure is created for asset condition that feeds an integrated data management system. This includes systemic data collection for sampling, testing, visual inspection, up-to-date inventory information and trending on equipment failure modes.
- Land rights, access roads and vegetation work is coordinated and integrated with program work, line upgrades, maintenance and environment
- Access roads program has robust preventative maintenance component and perpetual rights to land are obtained

Steady State – Success Vision

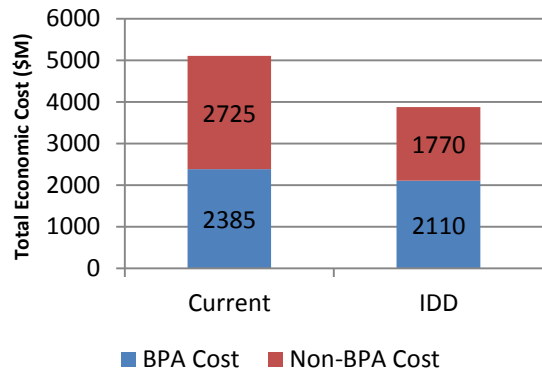
Through a situation assessment with key stakeholders, success has been defined as:

- Having a defensible budget, long-term visibility on replacements and maintenance work and stable amounts of sustain work each year based on economic lifecycle replacement, bundling and addressing repair and replacement backlogs
- A completed, end-to-end asset register that aggregates data across systems, so replacements are proactive and condition-based. This is enabled by data collection structure and integrated data management system.
- An access road infrastructure adequate to perform emergency, planned and routine line work in a timely and cost-effective manner.

Efficiency Improvements

- Condition data analysis and gap identification to begin creating the data collection structure
- Enabling information-based decision-making for prioritization and replacement plans
- Aligning reactive maintenance with total economic cost strategy
- Lines and rights-of-way expense budget based on system needs
- Access roads maintenance pilot to perform expense work and create a mechanism for preventative maintenance for roads
- Engineering-driven expense pilot program for lines to start addressing the repair backlog

PV of BPA vs. Non-BPA Cost for Lines & ROW Strategy (\$M)

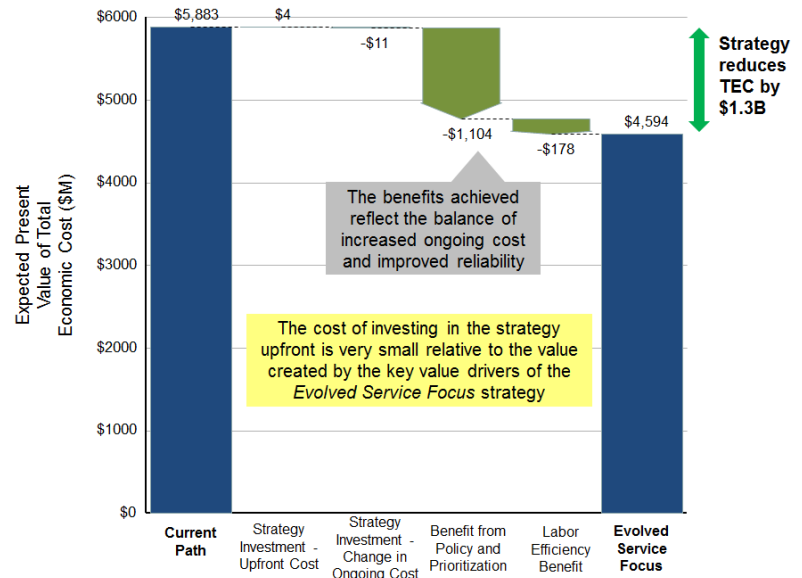


Control Center – Evolved Service Focus

In FY2015, subject matter experts came together to determine a control center strategy. After considering various strategy alternatives, the Evolved Service Focus strategy was selected. Compared to the previous strategy (Current Path), Evolved Service Focus reduces total economic cost by \$1.3B over a 27 year timeframe, given the shorter life of control center assets.

Main attributes of this strategy

- Optimal policy on the level of work for a year-over-year increase in spending that allows work to be delivered and avoids degradation in service performance
- Prioritization criteria are set in place on the basis of service lifecycle support needs and service-level costs benefits for all funding opportunities using total economic cost
- A standardized, multi-layered architecture plan, coordinated within and outside of Operations and supported by clear roles, responsibilities and processes
- Service strategy and planning is tied into organizational activity with a governance structure that focuses on requirements for the Operations Technology Services organization
- A methodology is adopted to evaluate service enhancements



Steady State – Success Vision

Through a situation assessment with key stakeholders, success has been defined as:

- An established policy on the level work with decreased degradation in service performance
- Architecture planning and design is formalized within a service frame
- Service strategy and planning is a formal role integrated into the organization
- Service enhancements that are evaluated through a methodology that is utilized as a standard

Efficiency Improvements

- Create policy on the level of work for year-over-year spending increases
- Develop an architecture plan with supporting roles
- Integrate the service strategy and planning role into the Transmission Operations organization

Program and Process Improvements

Asset Management and Program Delivery

The purpose of the AMPD initiative is to deliver new capabilities that will enable Transmission Services to fulfill the vision of “managing assets and investments to deliver the right work, at the right time, at the right cost with certainty.” Systemic obstacles were identified within the current asset information, asset planning and project delivery practices to achieve this vision. AMPD will detail and drive the changes in processes, roles, responsibilities, technology and tools to mitigate obstacles and enable the business to realize this vision by 2018.

There are six high value projects that are focusing on the following deliverables:

- Project scoping stage – Formalize project scoping in the process and develop systems and tools to adequately scope. Perform detailed scoping earlier in the acquisition phase to identify project execution opportunities as well as challenges and conflicts, thereby reducing waste and re-work.
- Project engineering function – Develop the capability to perform thorough project scoping.
- Estimating improvements – Increase the accuracy of estimates by performing the right level of estimate at the right time in the project.
- Portfolio management – Develop the capability in one function to manage capital investments and budget at the portfolio level rather than project by project.
- Stage gates – Develop formal control points in the process to re-evaluate whether and when a project should continue.
- Asset information – Develop an asset information strategy for how we collect, share use, and manage asset data and information to support both strategic planning and life cycle delivery activities.

Performance Measures

Transmission Services has adopted key system performance measures and targets to monitor the overall reliability, adequacy and availability of BPA’s transmission system (shown in the figure below). These system performance measures and targets are tracked in Transmission’s balanced scorecard and supplemented with asset program-specific metrics contained in the sustain program strategies.

	Performance Measures	End Stage Targets
Reliability	Excursion Minutes Over System Operating Limits Minutes of actual path flow over System Operating Limits (SOL) are to remain within targeted limits. Indicates congested areas for which capacity expansion may merit consideration.	The number of minutes with excursions of actual path flows (MW) above System Operating Limits on six key paths (COI, Northern Intertie, and four internal flowgates) is lower than targeted levels. Targets are unique for each path.
	System Operations Reliability No involuntary curtailments of firm load, system security breaches, or cascading outages originating on the BPA system.	No involuntary curtailments of firm load due to transmission system security breach of a security enhanced Tier 1, Tier 2 and Tier 3 Critical Asset. No involuntary load loss due to unplanned cascading outages triggered by the loss of a single transmission element. No load is lost due to a high, medium or low reliability violation.
Availability	Unplanned Outage Frequency and Duration (Pilot) Provides an indication of BPA's success at minimizing the frequency and duration of unplanned transmission line outages. Line voltage has replaced line rank, which was reflected in SAIDI and SAIFI.	The frequency and duration of unplanned transmission line outages for higher-voltage lines (≥ 200 kV) and lower-voltage lines (< 200 kV) are lower than targeted levels; and a list is created of lines with the worst performance during the fiscal year.

	Performance Measures	End Stage Targets
Adequacy	<p>Optimal Path Usage</p> <p>The percentage of time that actual flows (MW) on key paths is to remain within targeted levels. Path Usage is defined as the actual flow on a given path as a percentage of that path's dynamic SOL.</p>	<p>The percentage of time that actual flows (MW) on six key paths (COI, Northern Intertie, and four internal flowgates) are within 50-90 % of System Operating Limits is higher than targeted levels.</p>
Process Improvements	<p>Asset Management Key Performance Indicator</p> <p>Strategic Priorities Ways and Means – Execute implementation plans and enable the organization to more efficiently and effectively do the work.</p>	<p>Per the approved Asset Management and Program Delivery initiatives – processes, tools, and policies in support of asset register improvements; asset strategy development; and more successful project, portfolio and program delivery will be integrated and operationalized in the business organizations to enable effective Asset Management, planning and program execution.</p>

Risks

Transmission risks under BPA's Top Enterprise Risks

The long term goals for asset management and the Transmission Strategic Priorities strive to close gaps within Transmission Services. While the strategic approach section describes efforts underway to close many of the gaps, many of the risks to achieving the recommended objectives reach across all of BPA. The following are a few of BPA's Top Enterprise Risks that will have an impact on when and how Transmission Services will meet the goals of the System Infrastructure Strategic Priority. Success is contingent upon the development of a BPA overarching approach for mitigating the effects associated with these risks.

- Addressing the changing business environment through Focus 2028
- Workload and resource balance
- Talent adequacy
- Regulatory and compliance continued evolution

While not insurmountable, other risks to the objectives will take substantial time to define and develop feasible mitigation plans.

- Dependencies with external agencies and organizations (Bureau of Land Management, U.S. Forest Service, tribal partners, etc.) to meet regulatory needs such as permitting, in a timely manner for adequate project planning and implementation
- System operational impacts of needed outages to perform replacements in relation to availability requirements
- Asset register deficiencies and the time needed to correct may not fall into strategic timeframe

Risks in relation financial constraints

Asset replacements take 2-7 years of planning and execution. Long-term certainty in capital funding is required to efficiently implement replacements based on the strategic approaches mentioned earlier. Less than optimal funding levels contributes to the backlog and slows the replacement pace, which prolongs the program reaching a steady state toward a more proactive approach for risk mitigation.

This delayed pace also contributes to increases for corrective repair costs for maintenance.

AC substations, one of the most critical programs identified from the total economic cost strategies, is currently working to address a ~\$800M backlog of equipment beyond its expected lifecycle. From FY2014-2015, the AC substations program had 75 emergencies, including major failures in critical and costly assets such as reactors and transformers, and this number is expected to continue to grow until a steady state is reached. Based on the current funding trajectory of the sustain capital budget, 10-20% of the sustain capital budget is projected to address emergencies and unplanned work, per an assessment conducted by the Strategic Decisions Group (SDG) in October 2015.

Another example of risk to system reliability is the potential for increased fiber outages. In FY2015, BPA experienced 30 fiber outages as compared to the average of 10 per year from 1999-2009. Analysis has shown 40 fiber outages per year means BPA can expect two simultaneous fiber outages on the same ring, which is almost certain to result in transmission curtailments. This in turn would mean a reduction of load that can be served and reduction of generation allowed on the system; both of which would reduce revenues and damage reputation. Under the base levels in the short term, only 100 miles of fiber can be replaced per year, when the system need is 150-200 miles to mitigate outage risks.

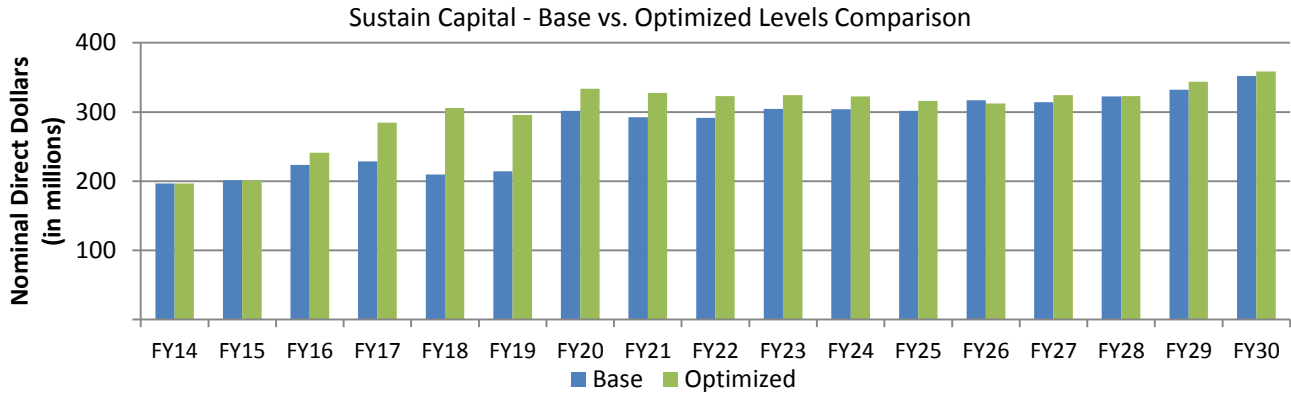
Increasing backlogs of equipment replacements and equipment failures run the risk of long-term consequences in terms of increasing total economic cost and a risk in deterioration of transmission system reliability. In the short-run, the risk of increase backlogs may seem relatively minimal but the cumulative risk over the long-term must be considered. The system could reach a tipping point where the size of the backlog cannot be addressed in the short-run due to constraints on taking planned transmission outages to perform the replacements.

Spending Levels

Sustain Capital Base Levels vs. Sustain Capital Optimized Levels (preliminary)

The base capital levels for FY2017-2019 are predicated on FY2014 CIR levels, which only include total economic cost strategies and models for SPC and PSC; all other programs submitted levels based on SME judgment and historical actuals. AC substations, steel lines, wood pole lines, access roads and control center total economic cost strategies and models were completed in FY2015. For FY2017-2019 the base capital levels average to \$218M per year, approximately \$230M less than what the system needs are in the optimized levels. The FY2020-2030 base levels attempt to ramp back to alignment with the optimized levels with an average of \$312M per year. The FY2016-2030 sustain capital optimized total is ~\$430M more than the total in the base levels.

Base levels put BPA's ability to achieve the benefits of the total economic cost asset strategies at risk. Both the critical high value replacements and the efficiency improvements require capital and expense funding represented in the optimized spending levels to execute the strategy at the right time, at the right cost, to maintain reliable transmission service to the region.



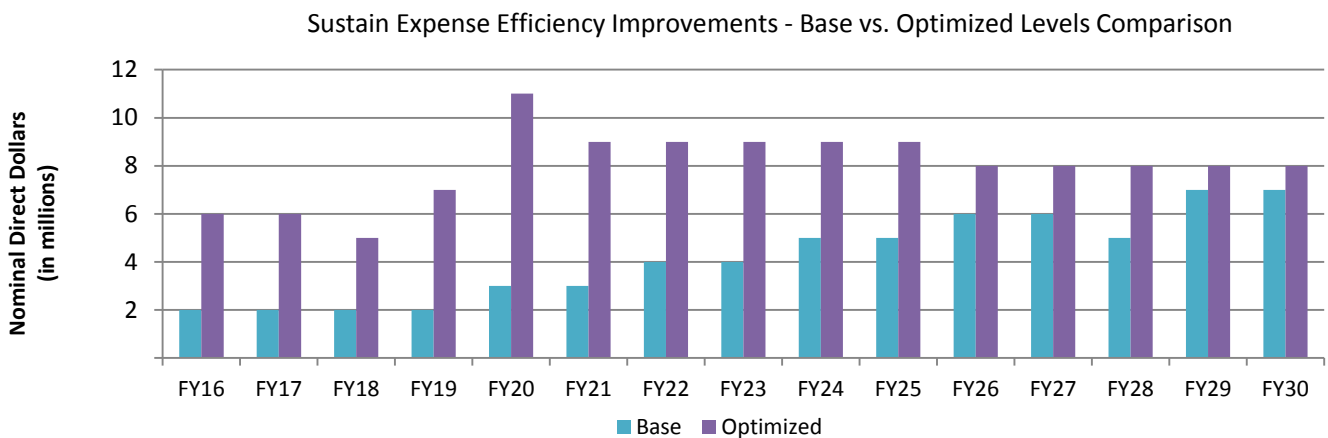
Sustain Capital (\$M)	FY14 Actuals	FY15 Actuals	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	Total FY17-30
Base	197	201	223	229	210	214	302	292	291	305	304	302	317	314	322	332	352	4,086
Optimized	197	201	241	285	306	296	333	328	323	324	323	316	312	324	323	344	358	4,495
Variance			18	56	96	81	32	35	32	20	18	14	-5	10	1	11	6	409

Sustain Expense Efficiency Improvements (preliminary)

The following chart is the expense base levels for strategy efficiency improvements mentioned in the Transmission Sustain Strategies section of this document. Examples include, but are not limited to:

- Pre-deployment testing, training and documentation for PSC
- Inventory assessments for SPC to contribute to asset register efforts
- Predictive analysis using cameras, sensors and monitors in substations
- Circuit breaker and transformer Electric Power Research Institute (EPRI) asset management tools to provide advanced analytics on maintenance and reliability
- Maintenance expense pilot for access roads and an engineering-driven expense pilot for lines
- Condition data analysis and gap identification for lines
- Policy creation on the optimal level of work for a year-over-year increase in spending that allows work to be delivered and avoids degradation in service performance for control centers
- Formalized architecture planning and design within a service frame for control centers

These improvements will increase efficiencies in implementing the base capital replacement plan. The FY2016-2019 levels only cover PSC pre-deployment testing, training and documentation efficiency

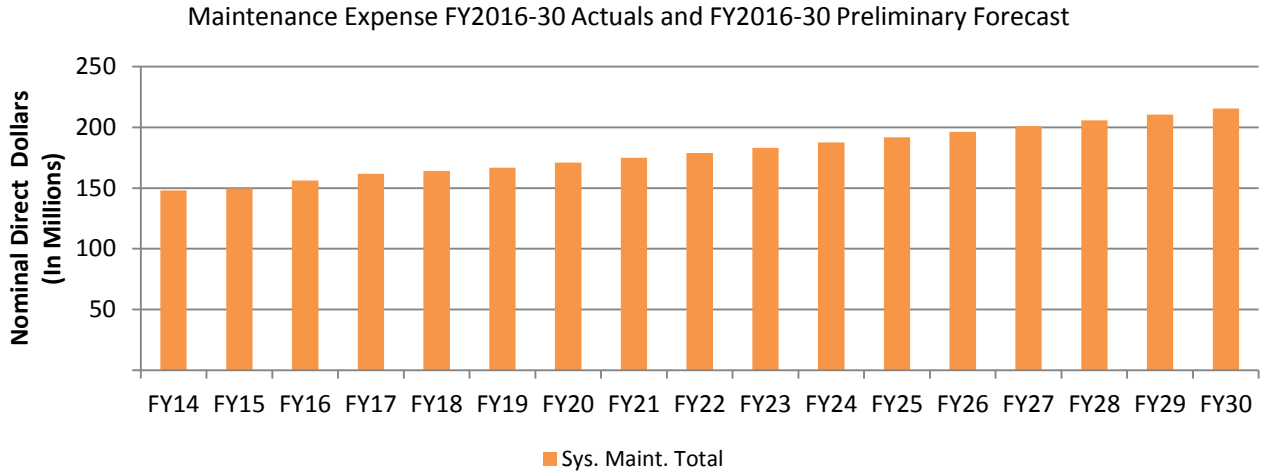


improvements due to funding constraints. All other process improvements will ramp up in the FY2020-2030 out years.

Efficiency Improvements (\$M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	Total FY17-30
Base	2	2	2	2	3	3	4	4	5	5	6	6	5	7	7	61
Optimized	6	6	5	7	11	9	9	9	9	9	8	8	8	8	8	114
Variance	4	4	3	5	8	6	5	5	4	4	2	2	3	1	1	53

Sustain Expense Base Levels (preliminary)

The basis for the expense levels below is FY2014 IPR Reference Case for the System Maintenance Program. FY2017-2019 represents system maintenance levels proposed for BP18, plus control center expenses that are represented in the System Operations Program.



Program	FY14 Actuals	FY15 Actuals	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29	FY30	Total FY17-30
Sys. Maint. Total*	148	150	156	162	164	167	171	175	179	183	188	192	196	201	206	211	216	2,610

*Non-electric sub-program costs are not included in the levels above as they are for facilities.

Financial Disclosure

This information was made publicly available on June 10, 2016 and contains information not sourced directly from BPA financial statements.