Technology INNOVATION

July 2015

PATH TO SUCCESS

BPA's R&D goals are driven by technology roadmaps and focus areas that are explicitly linked to current business challenges and technology gaps.

DELIVERING VALUE TO THE NORTHWEST

BPA's research program solves BPA challenges and enables breakthroughs through operational improvements, increased efficiencies and avoided costs — all of which help maintain affordable, reliable power for the region and lessen impacts to the environment.

DISCIPLINE

BPA's Technology Innovation Office carefully manages the agency's research portfolio through a robust screening and review process. The annual portfolio is a balance of projects that spans across various technologies, time horizons, risk/reward profiles and cost concerns.

COLLABORATION

BPA partners with utilities, researchers, universities and technology developers.

GROWTH

BPA expects to ramp up its research and development budget to approximately $18 million a year over the next several years.

Solving complex challenges

Bonneville Power Administration's technology innovation agenda is guided by a strict logic and framework that links the agency's research goals to current business challenges and technology gaps facing the agency. BPA's technology innovation agenda supports three of the agency's strategic priorities:

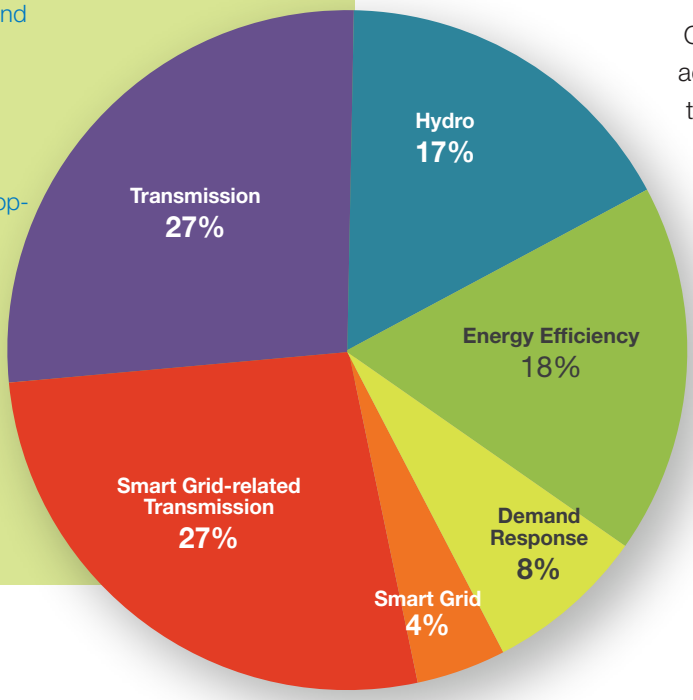
- Preserve and enhance generation and transmission system assets and value
- Advance energy efficiency
- Expand balancing capabilities and resources

Since 2005, BPA's Technology Innovation Office has pioneered an approach that ensures the agency is making shrewd investments in technology research. As the agency's chief technology innovation officer, Terry Oliver led the creation of a research discipline unique to the electric utility industry. "We borrowed ideas from companies whose very existence depends on good outcomes," Oliver explains.

One of the best practices BPA adopted from top companies was the development of roadmapping, which is a process the agency now relies on to drill down on immediate and future technology needs. To date, the agency has developed technology roadmaps for energy efficiency, hydroelectric operations, physical security and transmission planning, operations and design.

FY 2016 Technology Innovation Portfolio

(by investment category and percentage of total budget)

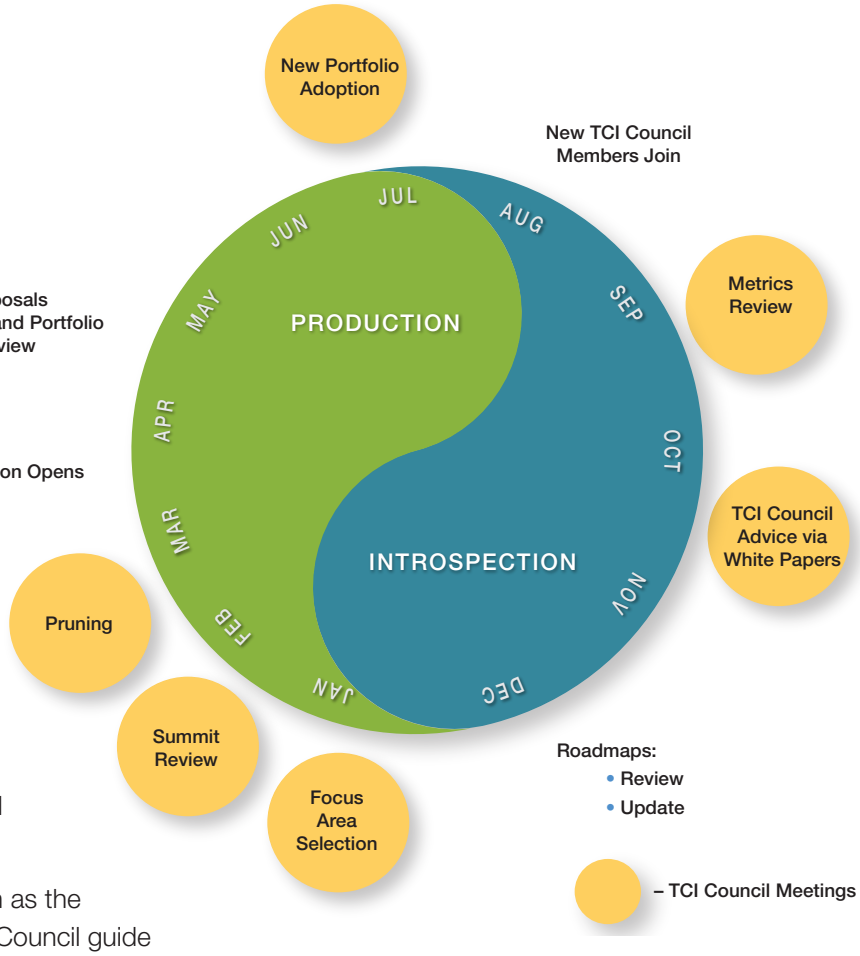


Research cycles

BPA has established an annual cycle of research and development funding that begins with a review of current projects in February, a solicitation for new projects for the following fiscal year from March to May, technical reviews of proposals in June, and selection in July.

"As an engineering oriented enterprise, we're often confident that new technologies will work, eventually. But real life shows us that just isn't always true," Oliver says. "So we've built an approach that keeps us focused on what matters, builds in metrics and decision points so optimism doesn't overcome reality, and an annual review and pruning task that keeps project managers on their toes. The result is an unprecedented level of success."

Technology Innovation's annual cycle



A group of executives and experts known as the Technology Confirmation and Innovation Council guide the development of the portfolio, which includes projects with varying options for success in the near-, mid-, and long-term. Each project has predefined stage gates that trigger decisions for continuation, revision or termination. This process helps ensure each project is on course to accomplishing its objectives.

Successes

Ductless Heat Pumps

Northwest residents are saving millions in heating costs following the success of BPA's ductless heat pump pilot program. Since 2008, more than 21,000 units have been installed. More utilities are incentivizing homeowners to buy them and hundreds of contractors are now qualified installers. And if the trend continues, ductless heat pumps could save the region an estimated 81 average megawatts of energy or about $52 million by 2029.

Ductless heat pump systems use 30 to 50 percent less energy to heat homes than electric-resistance or forced-air systems.

BPA linemen install a helical connector shunt on the Midway-Vantage 230-kV line in central Washington, north of Hanford.

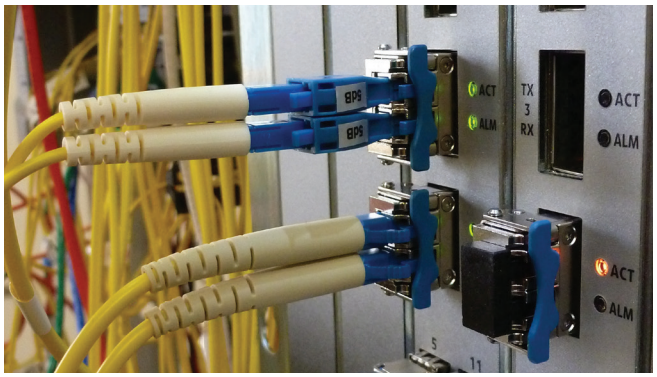
Helical Connector Shunts

The BPA-designed helical connector shunt is an industry achievement that's saving electric utilities and ratepayers millions. BPA engineers discovered that strands of aluminum can provide another path for electric current to travel, which relieves strain on components and increases the amount of electricity a high-voltage power line can carry. This BPA innovation allows electric utilities to repair or upgrade existing transmission lines instead of replacing them with costly, new lines. Since 2007, BPA has installed shunts on several lines and realized cost savings of nearly $20 million.

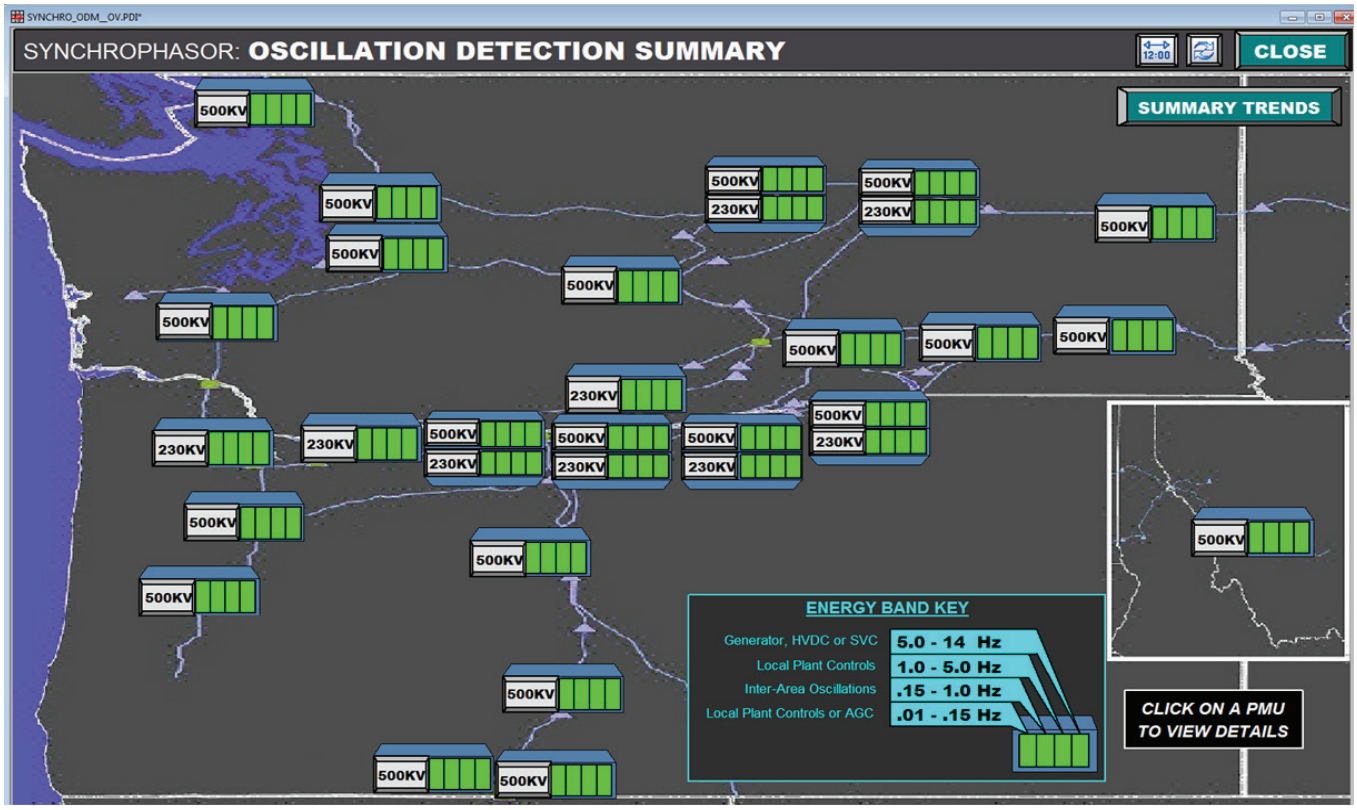
Benefits of the Connector Shunt Project	
Ross-Lexington Line	Restored 20 miles of conductor $4,000,000 savings Ampacity from 1070 to 1500 Amps Avoided 3 month outage
Midway-Vantage Line	Deferred reconductoring for 3 years Avoided reliability violation
Taft-Hot Springs Line	Reinforced connectors on 68 miles of line Extended service life 40 years $13,000,000 savings Avoided multi-month outage
Walla Walla-Pendleton Line	Upgrading 9 circuit-miles $15,000,000 savings Avoided up to an 18 week outage

Operational Multi-Gigabyte Ethernet Transport

BPA is upgrading its telecommunications network to support increasing demands for both information and more sophisticated applications. BPA's new Operational Multi-Gigabyte Ethernet Transport system enhances reliability and efficiency of system operations and allows integration of essential applications and systems, including synchrophasor and intermittent generation data and demand response programs. OMET provides a three orders-of-magnitude increase in available bandwidth (a thousand fold increase) and slows capacity depletion of BPA's existing Synchronous Optical Networking sys tem, avoiding a $15 million upgrade. BPA expects to fully deploy the OMET system by the end of 2017.



On BPA's legacy SONET system it takes about six hours to transfer 4.5 gigabytes of data. Whereas OMET can move the same amount of data in just over three seconds, at 10 gigabits per second.



This control room display identifies low-frequency power variations that can make the grid unstable, limit the transfer of power, and even cause system separation if they go unchecked. BPA's oscillation detection application monitors 136 synchrophasor measurements for excessive oscillations on the system.

Synchrophasors

BPA is using smart-grid devices known as phasor measurement units or synchrophasors to operate the Northwest power grid more efficiently and reliably. In 2013, BPA completed the build out of the largest, most sophisticated synchrophasor network in North America.

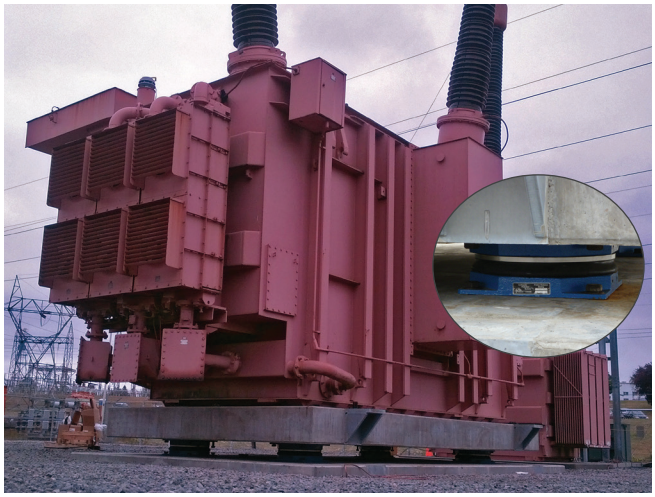
BPA has installed 126 phasor measurement units at 50 key substations and large wind generation sites throughout the Northwest. These shoe-box sized devices transmit precise power system data 60 times a second, giving operators a wide-area view of the system.

BPA now receives a hyper-feed of power system data from 126 PMUs throughout the region that provides grid operators real-time intelligence so they can react more quickly to system disturbances and take actions to avoid a blackout or prevent a disturbance from cascading. Furthermore, BPA analyzes the PMU data to enhance both transmission and generation systems, better integrate renewable energy such as wind, and to spot potential equipment trouble of power generators connected to its system. BPA's PMU research is also leading the development of generator model validation, which will unlock hundreds of millions of dollars in additional revenue, and the detection of oscillation modes which are not visible with present equipment.

Seismic Mitigation

BPA invests in seismic strengthening and hardening technologies to minimize the damage an extreme event would have on the Northwest electric grid, such as the Cascadia subduction zone earthquake, similar to recent earthquakes in Japan and Chile, which experts say is long overdue.

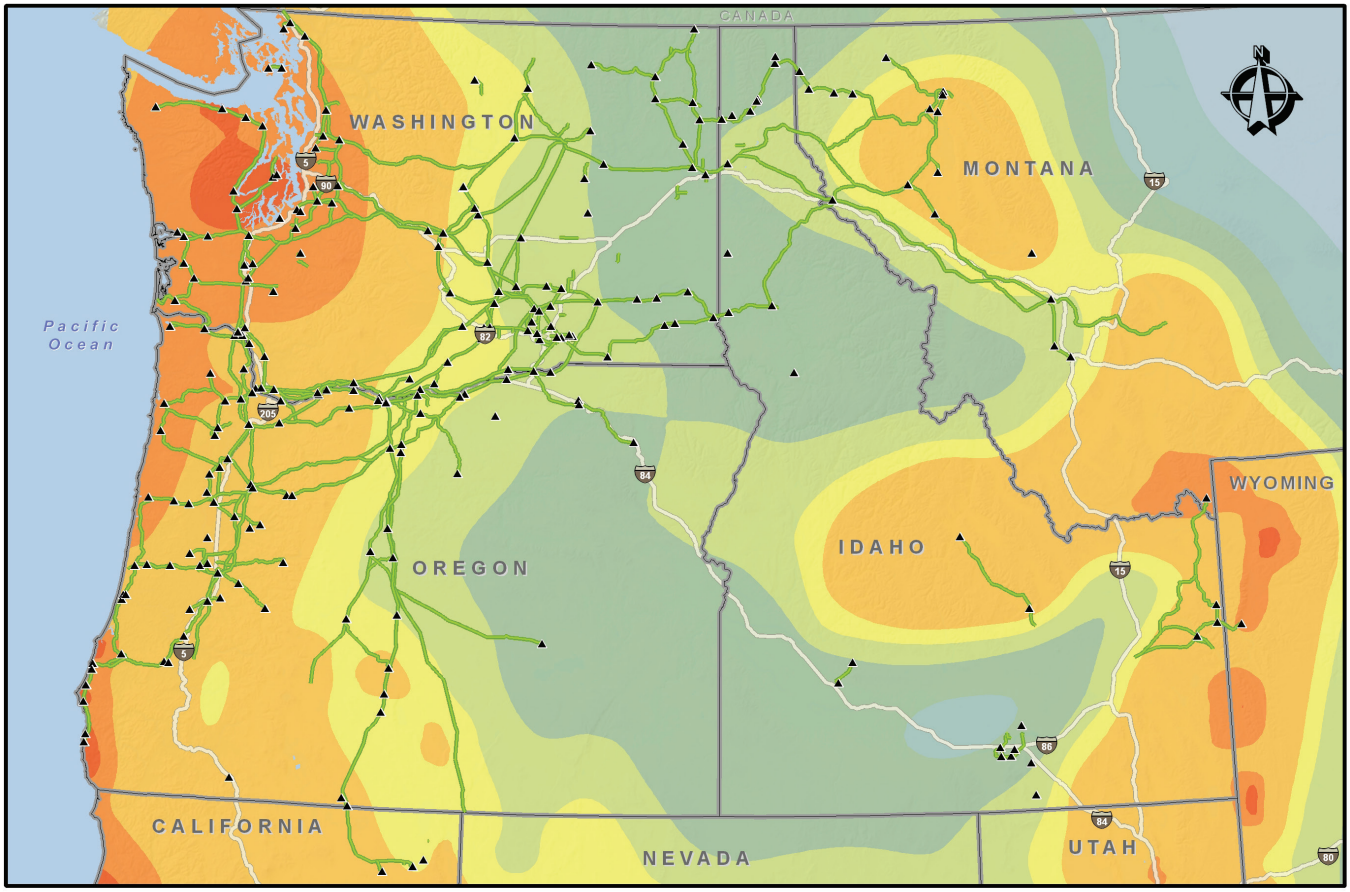
BPA's Technology Innovation Office began funding seismic mitigation projects in 2005 as a part of an Electric Power Research Institute-led effort to estimate the seismic risk of substation equipment. Since then TI has funded research that tests seismic performance, including supplemental damping and base isolation of high-voltage substation equipment. BPA has also developed engineering tools that assess the Northwest power system's vulnerability to extreme events such as earthquakes, landslides, liquefaction, and wind and ice storms. BPA's seismic mitigation program includes hardening of critical facilities, anchoring high-voltage transformers, protecting substation equipment, and creating model validation tools for seismic assessment of structural systems. In an extreme event these upgrades will help BPA restore the system sooner and save the region hundreds of millions of dollars in avoided replacement costs.



In 2013, BPA designed the first base-isolated transformer in North America and the first in the world using triple friction pendulums. The new technology could be used for future mitigation and standard transformer installation.

Inset: Installed base isolation bearing.

Seismic Hazards in the Northwest



The brighter-colored areas indicate the seismic hazards zones in BPA's service territory.

Collaboration

BPA partners with electric utilities, universities, technology developers, researchers and other industry partners in projects that address technology gaps and support the agency's strategic priorities.

Partners (past & present)

Regional, National and International

- Battelle
- CEA Technologies Inc. (CEATI)
- Fraunhofer Research Institute (Germany)
- Lawrence Berkeley National Laboratory
- Multidisciplinary Center for Earthquake Engineering Research
- National Renewable Energy Laboratory
- Northwest Energy Efficiency Manufactured Homes (NEEM)
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Pacific Northwest Smart Grid Demonstration Project
- Power Systems Engineering Research Center
- Sandia National Laboratories
- U.S. Deptartment of Energy
- Western Interconnection Synchrophasor Program

Electric Utilities

- Avista Utilities (Spokane, Wash.)
- Benton Public Utility District (Kennewick, Wash.)
- Clark Public Utilities (Vancouver, Wash.)
- City of Ellensburg, Wash.
- City of Port Angeles
- Eugene Water & Electric Board (Oregon)
- Flathead Electric Cooperative, Inc. (Kalispell, Mont.)
- Idaho Falls Power
- Lower Valley Energy (Afton, Wyo.)
- Milton-Freewater City Light & Power (Oregon)
- NorthWestern Energy (Butte, Mont.)
- Peninsula Light Company (Gig Harbor, Wash.)
- Portland General Electric (Oregon)
- Puget Sound Energy
- Seattle City Light
- Snohomish County Public Utility District (Wash.)

Universities

- Carnegie Mellon
- Cornell University
- Iowa State University of Science and Technology
- Lighting Research Center, Rensselaer Polytechnic Institute
- Oregon State University
- Portland State University
- Queen's University at Kingston (Canada)
- Rochester Institute of Technology
- State University of New York at Buffalo
- Texas A&M University
- University of Denver
- University of Illinois at Urbana-Champaign
- University of Washington
- Washington State University
- Washington State University Energy Program

Technology Developers

- Alstom Renewable Power Canada
- Cascade Energy, Inc.
- Deltares
- Ecotope Inc.
- GE Global Research
- Hitachi
- IBM
- Power World
- Powin Energy
- Primus Power
- QualityLogic, Inc
- Quanta Technologies
- SmartSenseCom
- Smith-Root Inc.
- V&R Energy Systems Research, Inc.

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- **Joshua Binus**, Policy Strategist, Corporate Strategy
- **George Brown**, Mechanical Engineer, Federal Hydro Projects
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