



Technology Innovation Office

Introduction & Overview

June 17, 2016



The Bonneville Power Administration (BPA) Technology Innovation Office (TI) manages the Agency's strategic approach to research and development (R&D). Recognizing that both flexibility and structure are integral to managing innovation and research, TI pioneered its approach to R&D in 2005, starting small, then learning and continuously improving. A decade later, the approach is highly refined, leading to R&D initiatives that align with BPA's strategic objectives and consistently:

- Improve BPA's finances by enabling technologies that reduce costs or increase revenues
- Clarify the business case and operational benefits of modernizing BPA technology
- Prepare BPA for vast changes the electric industry is experiencing

In 2016, TI produced a Handbook to document its tools and processes. The Handbook serves to standardize practices, record lessons-learned, provide a foundation for continuous improvement, and ensure knowledge transfer. Readers are encouraged to refer to the Handbook for more detailed treatment of TI's tools and processes. This Introduction & Overview complements the Handbook by providing a quick reference on:

- How TI's work aligns with the Agency's overall strategic goals.
- Importance of disciplined technology innovation to the utility industry.
- Outline of TI's "system of systems" technology management framework.
- Organization of the TI Office.
- Summary of the value TI's research has delivered to the Agency to date.
- Other innovative efforts led by TI.

The Agency's Chief Technology Innovation Officer (CTIO) heads TI and leads the agency strategy for how BPA researches, develops, demonstrates, and deploys new technology. Providing important guidance and key decisions are members of the Technology Confirmation / Innovation (TCI) Council, comprised of executives, managers, and subject-matter experts from across the Agency.

TI's annual budget target is set at one-half of one percent of BPA's gross revenue, a level not yet achieved. In 2015, the budget was approximately \$16.6 million. This funds the BPA cost share of projects in the R&D portfolio, as well as the cost of running the TI Office..

In 2015 TI managed over 50 projects in the R&D portfolio. Project areas included:

- Energy efficiency
- Transmission operations and planning
- Demand response
- Smart grid
- Hydro optimization
- Energy storage technology.

"... 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."

**Terry Oliver,
Chief Technology Innovation Officer,
Bonneville Power Administration**



Technology Innovation and BPA's Mission

In 2015 BPA transmitted about one-third of the electric power used in the Pacific Northwest. It also operated and maintained nearly 80 percent of the region's high-voltage transmission infrastructure. Technology innovation is a key element of BPA's mission to provide its service territory with *system reliability, low rates, environmental stewardship, and regional accountability*.

Technology innovation is important to the BPA's mission. Through fiscal year 2015, Technology Innovation was cited in the Key Internal Operational Capabilities section of the former BPA Strategy Map. In 2016 the BPA Introduced a new and simplified strategic framework to provide more focus and enable better prioritization. Although Technology Innovation is no longer explicitly included, it is clear that TI advances three of the five Key Strategic Priorities and related Key Strategic Initiatives (as outlined in Figure 1Figure): Physical Assets; Sustainable Finances & Rates; and Reliable, Efficient, & Flexible Operations.



Figure 1: The five BPA Key Strategic Priorities first established fiscal year 2016, with corresponding objective statements.

"I want to take a moment to say how proud I am to see BPA's TC/I Program continue to raise the bar for technology innovation both nationally and globally and I really appreciate all of your efforts. The disciplined portfolio management, technology roadmapping and focus on solving highly relevant business challenges are all hallmarks of a continually improving and highly sophisticated program. The program is also an excellent example of BPA's core value of collaborative relationships and has strengthened partnerships with key organizations and customers far and wide."

Elliot Mainzer
Administrator,
Bonneville Power Administration
(2015)



Importance of *Disciplined* Technology Innovation to Utilities

Rapid changes in technology. New policies and regulations. Evolving markets and business models. Climate change.

To be successful, the utility industry must profoundly and constantly adapt to both external and internal forces. It must invest in innovative technology. Within an industry traditionally risk-averse and inexperienced with structured innovation, BPA is a leader in *disciplined* technology innovation.

Balanced Approach

Innovation is messy. Most R&D projects fail. BPA's technology innovation program strives for a balance, with *enough of the messiness and inevitable failures* to encourage innovation and *enough structure* to manage the large investment to provide measureable outcomes and support business objectives and strategies.

The TI Office also balances its investments within a portfolio representing the Agency's business lines. While precise amounts vary year-to-year, a typical annual disbursement across the portfolio is shown in Figure 2.

"We are now at the beginning of a fourth major transition of electric services. The prior three were: electricity (Edison, et al); vertical monopoly (Insull, Tesla, Westinghouse, et al); markets (California, PJM, et al). The fourth (still very much a work in progress) is 'transactive.' (PNWSGD, AEP, SCE, NY PSC REV, GridWise Architecture Council).

Each of these transitions built upon technical achievements and also presented technical, conceptual, business, and policy challenges; this one is no different ..."

**Terry Oliver,
Chief Technology Innovation Officer,
Bonneville Power Administration**

Typical Portfolio Disbursement

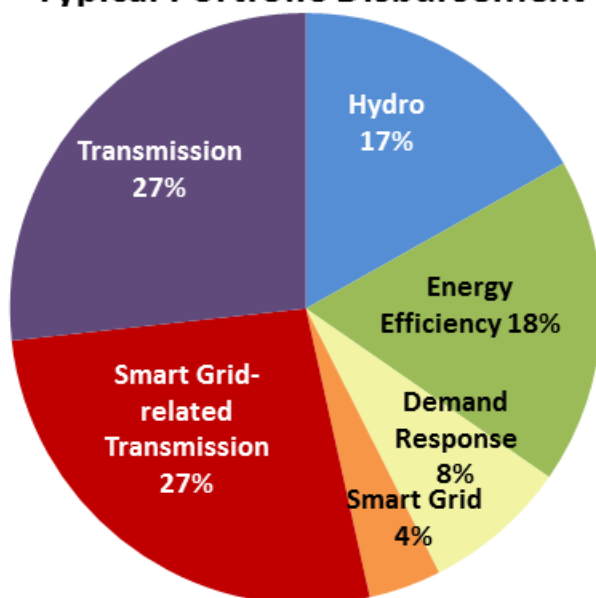


Figure 2: Typical disbursement among the BPA TI Office's technology R&D portfolio.



Funding for R&D

BPA allocates slightly less than one-half of one percent of its gross revenue to fund R&D. This level has been approved and endorsed by the executive team for the long term. TI benchmarks this spending level against the utility industry. The BPA spending is higher than most US utilities and lower than high-ranking international utilities (Figure 3). This is a 'sweet spot' and TI strives to allocate every dollar effectively.

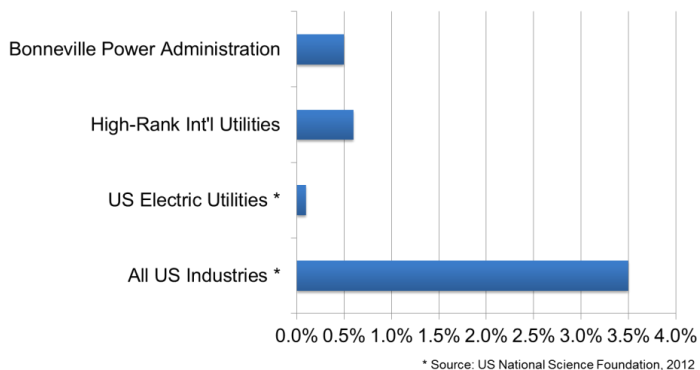


Figure 3: BPA spends about 0.5% of annual gross revenues on R&D.



Implementing Technology Innovation Management

TI applies a disciplined framework to link the BPA research goals with business challenges and technology gaps facing the agency. The four elements comprise the framework: *Roadmapping*, *Portfolio Management*, *Project Management*, and *Technology Transfer*. Figure 4 is a summary.

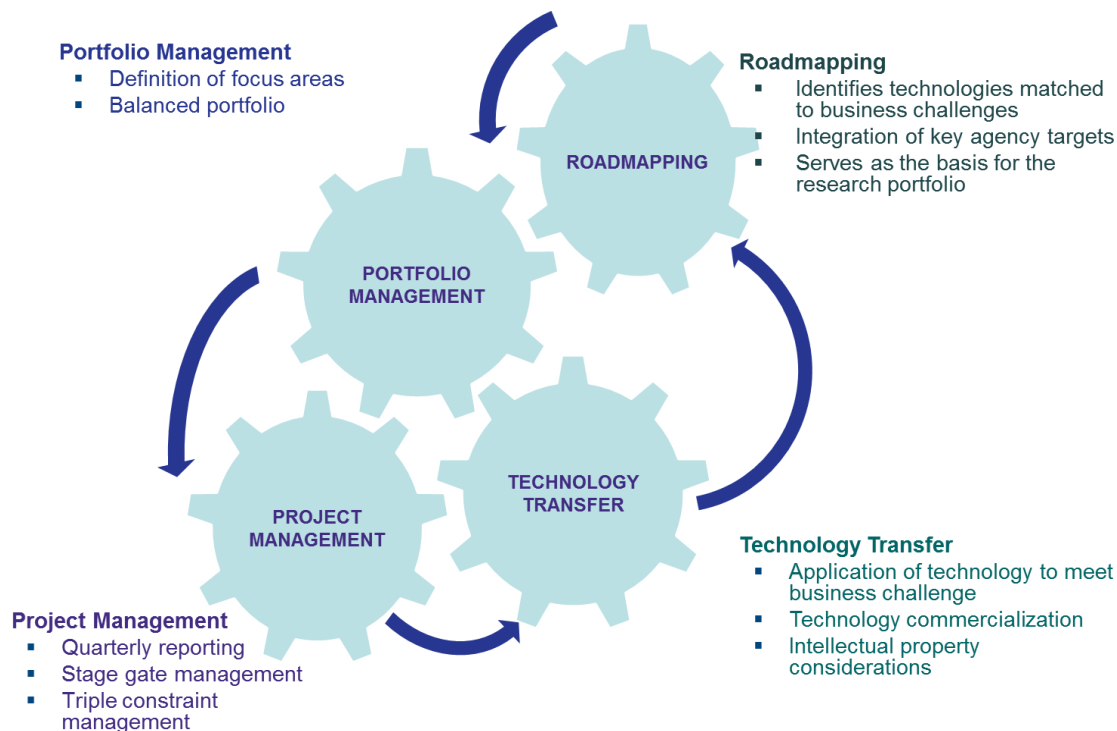


Figure 4: Technology innovation is an integrated process

Element 1: Roadmapping

TI begins the annual technology management cycle by facilitating the creation of detailed technology roadmaps based on with input from technical staff and Agency executives and experts from throughout North America. Roadmaps provide a publically-articulated research agenda communicating Agency needs to the international research community. They show diagrammatically the incremental and breakthrough R&D programs the BPA can pursue to achieve its strategic objectives and how these programs link to business drivers. In identifying business and operational challenges, technical needs, required capabilities, and associated R&D programs, roadmaps define the types of projects TI will invest in and, by extension, provide a foundation for the R&D portfolio.



Element 2: Portfolio Management

Guided by roadmaps, TI annually solicits proposals from researchers worldwide for research projects with the potential to fill identified needs. TI evaluates the proposals using carefully defined processes and constructs a balanced portfolio of R&D projects that are most likely to deliver high value to BPA.

One proactive portfolio management practice comes in the form of the BPA Technology Confirmation / Innovation (TCI) Council. The Council—comprised of executives, managers, and subject-matter experts—annually evaluates each proposed project using structured criteria to produce a balanced portfolio. After the TCI Council selects the portfolio, TI initiates, executes, and steers it.

“Linking actions to essential trends and drivers can also be done through a visual scheme. The Bonneville Power Administration TRM [technology roadmap] on efficiency technologies ... contains such visuals. They show how basic societal drivers are translated into desired product features. These are then translated into technology challenges, which lead to R&D challenges. This structured way of thinking is important for TRMs, and provided a good basis for the final step, not shown in the visual: the identification of concrete actions for BPA.”

**“Background paper on Technology Roadmaps (TRMs),” prepared for the Technology Executive Committee of the United Nations Framework Convention on Climate Change
March 8, 2013**

Element 3: Project Management

TI applies recognized project management practices to provide oversight and guidance for the execution of portfolio projects. Project managers monitor and influence project performance, and they facilitate collaborative engagement among the people working on their projects.

All project teams define and monitor appropriate stage gates to measure progress toward research goals. Project managers proactively balance constraints such as schedule, spending, and deliverables. They perform both formal and informal status and financial reporting.

Element 4: Technology Transfer

Technology transfer ensures that R&D results are applied to meet real BPA business needs. Without effective technology transfer, even highly successful R&D is useless. The TI technology transfer framework has four major objectives.

1. Direct application of Technology Innovation outcomes to BPA to benefit the Agency and regional stakeholders.
2. Disseminate knowledge and research results in a way that maximizes the value of R&D investments for the BPA business.
3. Capitalize on the BPA’s technological capability and knowledge.
4. Contribute to the utility industry and the region by sharing the BPA’s innovative technologies and applications.



Technology transfer planning for a project starts as soon as BPA awards the contract. The basis for technology transfer planning starts with a benefit management document. This document qualitatively identifies the potential impacted area for the research—will the technology address system reliability, will it increase energy efficiency, will it achieve some other Agency goal? The information is used to engage the right stakeholders as part of the R&D process thereby creating a sense of ownership in the technology. The benefit management document is continually updated and is used as an input to the capital project business case, as appropriate for the research.

A custom technology transfer plan is created for each project in the portfolio. It addresses how the research will eventually be commercialized or moved into production at BPA, as well as intellectual property and licensing considerations. The plan matures throughout the course of the project and is used to pro-actively addresses challenges to eventual technology application.

The TI Annual Cycle: Production and Introspection Phases

TI's integrated framework occurs within an annual cycle comprised of two phases. *Production* begins each December when TI prepares for the upcoming Funding Opportunity Announcement. The Announcement occurs in March, proposals are received and reviewed between March and June, and the upcoming fiscal year portfolio is awarded in July. *Introspection* occurs between July and December. It is a period to evaluate and improve upon internal processes, produce updated roadmaps, and work on other areas that will enhance the Production cycle, such as:

- Determine likely BPA future technology gaps.
- Identify what R&D can be done to fill those gaps.
- Decide what the upcoming portfolio should look like to meet the identified technology needs.
- Communicate process improvements to the TCI Council.

Figure 5 on the following page illustrates typical activities that take place during the cycle.



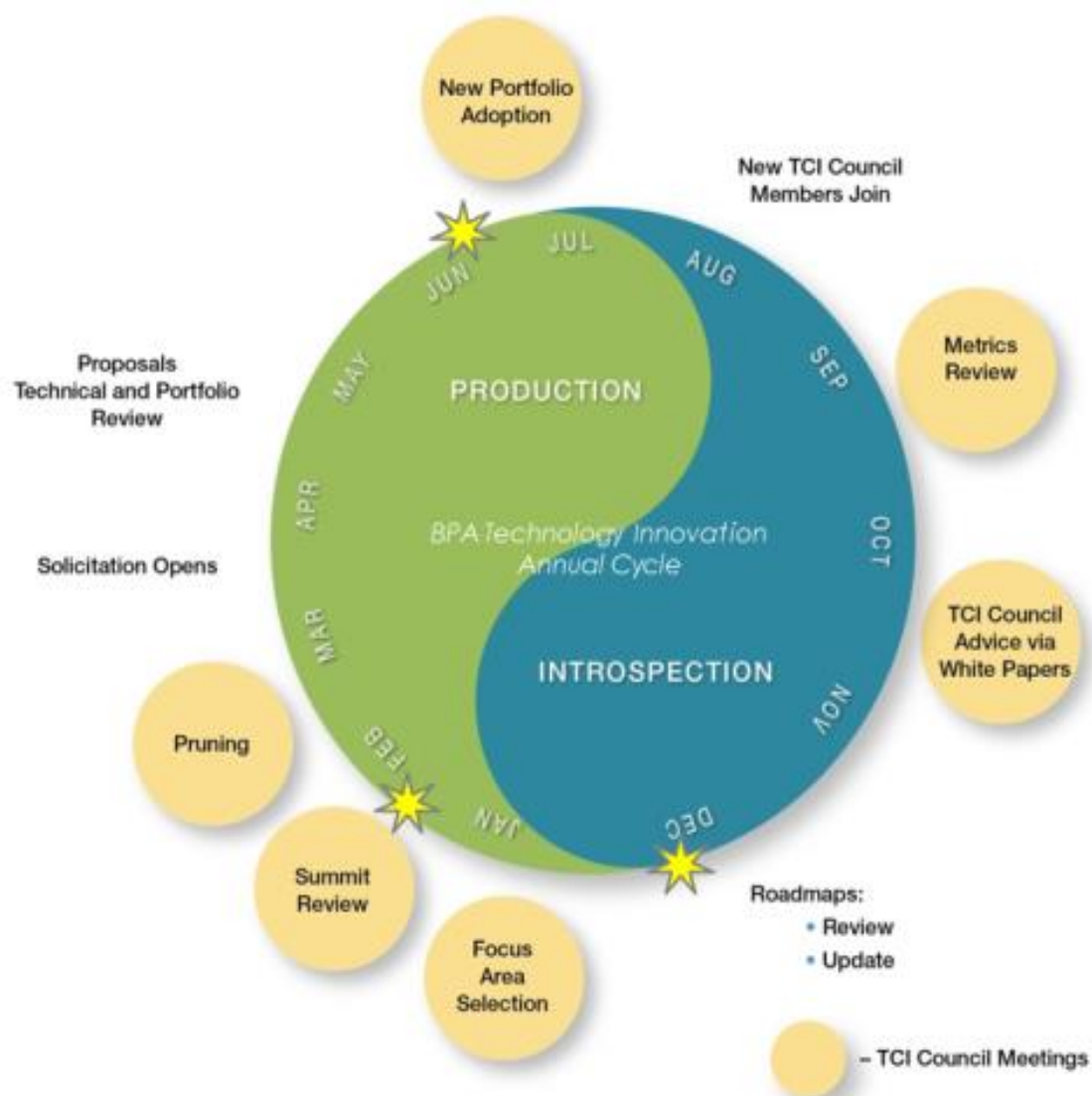


Figure 5: TI uses a cycle that contains introspection and production activities.



Organization of the TI Office

The core functions of the TI Office align with the four elements of the R&D framework: *Roadmapping, Portfolio Management, Project Management, and Technology Transfer*. TI staff fill a variety of roles within these functions, for example:

- Chief Technology Innovation Officer
- Portfolio Manager
- Project Management Officer
- Technology Transfer Manager
- Project Managers
- Roadmapping Project Manager
- Financial Analyst
- Management and Program Analyst
- Business Analyst
- Strategy Liaisons
- Administrative Assistant
- Contracting Officer's Technical Representative

TI staff are supported by many other people who work closely with them to run R&D at BPA. Figure 6 shows some of these roles.

ROLE	FUNCTION
Technology Confirmation/Innovation Council	members connect the technology innovation program to the interests and needs of BPA and the PNW region
TI proposal evaluators	reviews and rates proposals received in response to annual solicitation
Project sponsors	advocates and defends a technology innovation project as a valued investment that serves BPA's strategic objectives
Functional managers	provides resources and technical review for a technology innovation project
Project managers	facilitates project team to accomplish project objectives within given constraints
Subject matter experts	provides specialized expertise to a technology innovation project
Contracting Officers (CO)	ensures projects comply with BPA's supply chain requirements

Figure 6: Participation from outside TI is essential.

"I was surprised by the breadth of topics BPA is working on. The discipline and rigor of the effort will serve BPA and its Northwest customers very well, long into the future."

Chris Heimgartner
Chief Operating Officer,
Snohomish PUD
(2015)

"The process and discipline demonstrated at this TI review is very impressive. The topics are on target. And I was very pleased to see BPA taking a lead role in the region, especially in the area of grid resiliency."

Dr. Wayne Lei
Director, Research and Development, Portland
General Electric
(2014)



Delivering Value to BPA

The TI disciplined approach to R&D management has delivered approximately \$280 million in cost savings to date—\$70 million direct and \$210 million indirect—for an investment of about \$70 million (see Figure 7). The TI Office ramped from an annual budget of ~\$6 million with no portfolio in 2006 to ~\$16 million with a disciplined “system of systems” approach by 2016

More than 300 projects have come through the TI portfolio, and just three of these returned the entire \$70 million cost of the TI program:

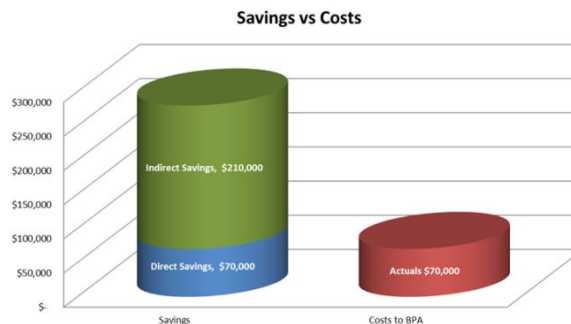


Figure 7: Cost and savings comparison of the TI Office's R&D investments, 2006–2016..



Helical conductor shunt

BPA-engineered technology to extend the life of aging transmission lines, minimize outages required for line reconstruction, and enable more power sales over constrained transmission lines. \$34 million in direct cost savings, more than \$6 million in savings from avoided planned outages.



Operational Multi-Gigabit Ethernet (OMET)

Communications via BPA optical fiber network ensures compliance with NERC-CIP requirements and enables operationalization of high-bandwidth synchrophasor network; \$36 million in direct savings with significant additional benefits including greatly enhanced system visibility and avoidance of cascading outages.



Ductless heat pumps (DHPs)

BPA TI contributed to regional collaborative energy efficiency technology assessment launched in 2007 for residential applications, with initial success resulting in expansion into small commercial applications; since 2009, more than 121,000 DHPs have been sold in the Pacific Northwest resulting in \$2 million in direct savings and \$15 million in avoided regional generation costs.

The TI success serves as a model for other utilities and has led to significant achievements and recognition for BPA staff, the TI Office, and the Agency as a whole, including:

Synchrophasor breakthroughs at BPA signal quantum leap in grid reliability

BPA research recognized with the Platts Global Energy Award for grid optimization (2013) and the North American SynchroPhasor Initiative (NASPI) “Outstanding Utility of the Year” award (2014).

“The nurturing and support of new technologies and business innovations helps Bonneville, Western and electric utility partners remain forward looking.”

Subhash Paluru
Senior V.P. and Regional Manager,
Western Area Power Administration
(2016)



BPA seismic research leading industry standards

The first base-isolated transformer in North America, and it's one of a few in the world; Snohomish PUD adopted this technology and is currently installing the BPA's base-isolation devices.

Showcasing BPA's achievements

American Builders Quarterly, *Northwest Public Power Association*, and *Transmission and Distribution World* recently published articles featuring the Agency's research success, technology deployment experience, and project management best practices.

Disciplined Agency technology management practices recognized

The United Nations Framework Convention on Climate Change (2013) identified the BPA's roadmapping process as a good practice in clearly linking drivers with technology R&D needs.

The TI Office is proud of the many ways it continues to make a difference. Some guiding principles:

- Change is the constant: innovation is essential.
- Failures are expected . . . but fail early and fail cheaply.
- Embrace a balance between the messiness of innovation and the discipline of a structured R&D program.
- Provide clarity. (See Figure 8)

TI emphasizes continuous improvement and has incorporated best practices from Intel, Boeing, General Electric, Jet Propulsion Laboratory, and the Pacific Northwest National Laboratory, especially in these five areas:

- Technology roadmapping
- Portfolio management
- Portfolio pruning
- Stage gates
- Project management

Looking toward the future, TI plans to get even better at managing and communicating about cost effective, innovative research that delivers needed solutions for the BPA. It will expand its influence on research practices in the utility industry and will always seek ways to improve its processes, including using internal and external assessments.

Clarity of purpose – what we are trying to accomplish must be known

Clarity of choice – good choices require good metrics – why is B more important than A?

Clarity of the system – Management requires systems – Brownian motion does not lead to good research

Figure 8: Clarity is essential.

"We borrowed ideas from companies whose very existence depends on good outcomes."

**Terry Oliver,
Chief Technology Innovation Officer,
Bonneville Power Administration**



Other Areas of Innovation

In addition to its core work, TI also invests in some other innovative regional efforts, such as:

Northwest Energy Experience Program (NW Energy XP)



The NW Energy XP communicates important opportunities and challenges the Pacific Northwest utility industry is facing to regional university faculty and students. University awardees then apply their research skills to projects involving real-world technical challenges. The program requires collaboration between the participating universities, helping build a regional network of engineering professionals attuned to utility needs. TI and Portland General Electric co-fund a grant to the Oregon Built Environment and Sustainable Technologies Center (OregonBEST) to administer the program.

Bonneville Environmental Foundation (BEF)

BEF is a non-profit organization based in Oregon that applies market-based approaches to support watershed restoration programs and develop renewable energy resources. BEF is partnered with BPA but functions as an independent organization.



For Inspiration and Recognition of Science & Technology (FIRST) Robotics

FIRST is an international non-profit organization committed to advancing science, technology, engineering, and mathematics (STEM) education through an annual network of robotics tournaments. BPA is a lead sponsor of FIRST Robotics, which organizes regional robotics competitions throughout Oregon and Washington for junior high and high school students, who form team to design, build, and program a robot to perform a series of challenges.



GRidEd West

GridEd is a national U.S. Department of Energy-funded program administered by the Electric Power Research Institute (EPRI). Through collaboration among utilities, government, and universities, GridEd is expanding to the western states to to train power engineers in developing, enhancing, and sustaining the grid of the future.



IBM Opus

Evolving out of IBM's Smarter Energy Research Institute, Opus brings together energy and utility companies to devise an innovative open analytics platform to help address uncertainty. It couples IBM's expertise in information technologies and "big data" with real-world energy industry needs to create actionable intelligence based on a probabilistic decision support system.

