

2015

## Opening the Door to Breakthroughs that Address Strategic Organizational Needs: Applying Technology Roadmapping Tools and Techniques at an Electric Utility

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### Citation Details

Hillegas-Elting, J. V., Oliver, T., Binus, J., Daim, T., Estep, J., & Kim, J. (2015). Opening the door to breakthroughs that address strategic organizational needs: Applying technology roadmapping tools and techniques at an electric utility. In 2015 Portland International Conference on Management of Engineering and Technology (PICMET) (pp. 2564–2573). IEEE.

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**Abstract**—Over the course of a decade, the Bonneville Power Administration's Technology Innovation Office has developed a roadmapping approach that captures business challenges and opportunities critical to the agency, links these with barriers to success, and connects these with technical solutions and research questions. Senior leaders from across the agency establish strategic goals and objectives, and international technical subject matter experts are convened to articulate technology-associated paths to achieve these. Each roadmap captures insights from diverse experts in highly collaborative environments and focuses them on critically important topics. These roadmaps are an important element in the Bonneville Power Administration's strategic approach to technology research and development.

### I. INTRODUCTION

In the face of evolving regional requirements, the ever-changing role of utilities, and shifting economic cycles, Bonneville Power Administration (BPA) leaders recognized the need for a robust and collaborative approach to technology R&D, and so created its Technology Innovation (TI) Office in 2005. Since this time, TI staff have proactively integrated best practices from academia and various industries to improve continually through communication, training, and benchmarking. Whereas the North American electric utility industry as a whole has not widely applied technology management practices to guide R&D investments, BPA has integrated these as a core element of an approach that links agency research goals to current business challenges and opportunities.<sup>1</sup> The result is a technology innovation agenda providing a strict logic and robust framework that supports three strategic priorities:

- Preserve and enhance generation and transmission system assets and value.
- Advance energy efficiency.

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<sup>1</sup> The Bonneville Power Administration (BPA) is a federal wholesale electric utility serving the Pacific Northwest. The U.S. Congress established BPA in 1937 to market and transmit electricity from federal hydroelectric dams within the Columbia River basin in the Pacific Northwest. This 300,000-square-mile (777,000 km<sup>2</sup>) service territory comprises the states of Oregon, Washington, Idaho, and western Montana. BPA is part of the U.S. Department of Energy but, unlike the DOE, receives its funding through wholesale power and transmission service sales rather than through congressional tax appropriations. As of 2013, BPA provided about 30 percent of the electric power used in the Pacific Northwest and also operated and maintained about 75 percent of regional high-voltage transmission infrastructure. For more information, see Bonneville Power Administration, "BPA Facts," 2013, <http://www.bpa.gov/news/pubs/GeneralPublications/gi-BPA-Facts.pdf>.

- Expand balancing capabilities and resources.<sup>2</sup>

An important element of this innovation agenda is the use of technology roadmaps. These are tools to help organizations articulate needs and plan for innovation in a comprehensive, strategic manner related directly to critical business drivers and market trends. Since first being applied at Motorola in the 1970s, many kinds of organizations have developed technology roadmaps with varied levels of focus to achieve their strategic goals; manufacturers, non-governmental organizations, academia, industrial associations, community groups, and government agencies have all tailored technology roadmapping methods to direct attention on the most relevant and promising technologies [3, 9, 11, 14, 15, 16, 17, 20]. These wide applications have been in a range of sectors including electronics, aerospace, defense, manufacturing, materials, paper products, semiconductor, software, information and communication technologies, and healthcare [12, 13, 14, 19, 20]. Utilities and others in the energy sector have also increasingly been developing technology roadmaps [1, 4, 5, 6, 12].

Roadmaps guide the BPA TI Office's annual solicitation for R&D project proposals and help sustain the agency's role as stewards of ratepayer funds by ensuring due diligence. Between 2006 and 2014, the TI Office has facilitated roadmap development projects that have brought together subject matter experts from within BPA; from beyond the agency to include regional stakeholders; and from beyond the region to include specialists throughout North America. In the aggregate, since 2009 BPA's technology roadmaps for energy efficiency, transmission, demand response, and power generation asset management have benefitted from the input of more than 430 people representing nearly 170 organizations.<sup>3</sup> Out of this experience has come a set of tailored processes and tools and a strong network of partnerships that has helped the agency refine its application of technology roadmaps to aid in strategic R&D planning.

### II. PROCESSES

Hands-on experiences gained while developing a series of energy efficiency technology roadmaps through 2012 enabled the TI Office and its partners to establish replicable

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<sup>2</sup> For more information about the BPA Technology Innovation Office and for access to PDF versions of all the technology roadmaps and supporting documentation discussed in this paper, see [www.bpa.gov/ti](http://www.bpa.gov/ti).

<sup>3</sup> The in-kind contributions from these experts are conservatively estimated at about (USD) \$1.5 million.

processes, approaches, and structures applied in 2013 and 2014 as part of roadmapping projects for transmission, demand response, and power generation asset management. These included:

1. tailoring workshop duration and scheduling to meet utility industry needs;
2. coupling the agenda with specific facilitation guidelines;
3. establishing a strong facilitation support team;
4. identifying participants and optimizing their time; and
5. establishing a steering committee for a centralized and proactive approach to planning.

### *A. Workshop Duration and Scheduling*

BPA TI Office staff began working with faculty and students from the Portland State University's Engineering and Technology Management Department (PSU) in 2005. After receiving guidance from PSU faculty and training with Dr. Robert Phaal of Cambridge University's Institute for Manufacturing in 2009, the BPA team tailored the methods, models, and best practices to meet the needs of the agency and, more broadly, the utility industry. This included adapting the multi-day workshop model into two workshops (with each workshop being just one day—or at most two days—in duration) and developing a highly-structured agenda to make the workshops as efficient and effective as possible.

The literature on technology roadmapping documents examples where firms have successfully applied approaches that include multi-day workshops. Scholars have found this model works well in sectors where the development of products and services occurs relatively rapidly and success in doing so is tied directly to a company's bottom-line financial health [7]. The utility industry is unique in comparison because of different opportunities and challenges. A utility's core business is not to develop a constant flow of new and improved manufactured goods or software into the marketplace. Utilities exist to provide safe, affordable, and uninterrupted electricity service. Because of this, many utilities take a more measured, risk-informed approach toward adopting new and breakthrough technologies.

Because electric utilities run their business in different ways, it is to be expected that technology roadmapping tools and practices proven at Motorola, International Semiconductor, and elsewhere would not be adopted without some refinement to suit different environments and cultures. Phaal observes as much when he notes that "In general it is necessary to customize the roadmapping approach to suit the particular circumstances for which it is intended" [13].

BPA staff modified the roadmapping approach to fit agency needs by establishing a three-step workshop structure that has typically included an executive sponsor workshop (or "principals' meeting") followed by two subject matter expert workshops (workshops 1 and 2) scheduled over a period of four to six months.

### *B. Principals' Meeting*

This meeting brings together the core group of executives and other senior-level managers to prioritize areas on which the roadmap project is to focus during a given phase. In the case of collaborative roadmap projects that involve more than BPA executive input, this group also includes senior-level representation from these other organizations. Viewing the landscape of potential areas (as represented in the "organizational chart," described in the section on Tools below), these decision-makers establish the conceptual structure of the roadmap, which, in turn, clarifies the kinds of subject matter experts who are asked to participate in the subsequent hands-on workshop(s). Depending upon what is needed, this meeting can be anywhere from one hour to one half-day in duration.

### *C. Workshop 1*

The goal of this workshop is to articulate key technology drivers and the capability gaps that exist in meeting those drivers. This input is best provided by those with strategic-level responsibility and vision such as executives, senior-level operational managers, and other "big-picture" experts who can help provide the context for changing economic conditions, pending regulations, business needs and challenges, and the like. Workshop 1 is at least one day long but, if needed, can be up to two days in duration.

### *D. Workshop 2*

This workshop brings together "tactical" subject matter experts to articulate technology characteristics required to bridge capability gaps and to describe R&D programs needed to develop these characteristics. This group generally includes those with day-to-day "hands-on" responsibilities, such as operational managers, engineers, operators, researchers, and academics. This group represents stakeholders such as utilities, universities, national laboratories, non-profit organizations, manufacturers, and vendors. Workshop 2 is also at least one day long but, if needed, can be as much as two days in duration.

### *E. Workshop Agenda and Facilitation*

To help make these shorter-duration and complementary series of meetings and workshops succeed, the project team has incrementally developed an agenda that strives to generate useful content as quickly and efficiently as possible from a diverse array of participants, many of whom have not yet met and are not familiar with technology roadmapping. Workshops 1 and 2 have the same basic structure to guide the content development process. This is true whether the workshops themselves are one- or two-day events.

Workshops always begin with a period of sixty to ninety minutes to welcome participants and ground them in foundational information they will need to know. This information includes BPA's role in the Pacific Northwest, the agency's technology innovation processes, and technology roadmapping fundamentals. It also covers a high-level review

of the project and decisions made during the principals' meeting. Starting with higher levels of generality, this period begins with a "big picture" overview of what BPA does and how the roadmapping tool fits into BPA's strategic approach to technology R&D planning; it ends by narrowing focus upon the specific roadmap deliverable that participants have convened to help create. This prepares them for the work of the day, which is structured by three objectives:

1. Objective 1: Develop consensus on teams and approach. The facilitator sub-divides workshop participants into smaller collaborative teams based on roadmap content. Participants are given about thirty minutes to finalize these teams, review roadmap structure, and prepare for work.
2. Objective 2: Identify swim lane content. The agenda includes focus questions applicable to each workshop to guide participants in articulating their drivers, capability gaps, technology characteristics, or R&D Programs. This content populates each "swim lane" in the roadmap diagrams (explained more fully below). Examples of focus questions for each include:
  - *Identifying key drivers.* What are the critical factors that constrain, enable, or otherwise influence organizational decisions, operations, and strategic plans? Factors can include existing or pending regulations and standards; market conditions and projections; consumer behavior and preferences; organizational goals and culture; and other strategic considerations.
  - *Identifying capability gaps linked to drivers.* What are the barriers or shortcomings that stand in the way of meeting drivers?
  - *Identifying technology characteristics linked to capability gaps.* What are the core characteristics of a piece of equipment, tool, algorithm, software program, product, service, or other technology that would help address the linked capability gap?
  - *Identifying R&D programs linked to technology characteristics.* What are the core elements of an R&D program that would deliver the linked technology characteristic(s), including a summary description and one or more key research questions?
3. Objective 3: Team presentations (Summary insights and conclusions). A strength of this approach to developing roadmap content is that it brings together diverse experts who actively collaborate by getting out of their chairs, engaging in discussions, generating content, and offering their colleagues real-time feedback, refinement, and debate. Much of the fruits of this dynamic, organic process are captured in the posters that are then transcribed and become roadmap content. Another effective way to document this expertise is by asking the sub-groups to provide brief verbal report-outs of about ten minutes, with five minutes for questions. This is to provide "cross fertilization" among the participants. Subgroups are specifically asked to describe the key

takeaways, summary highlights, and most important items and issues discussed. The facilitation team manages these sessions very closely to ensure that each sub-group receives the same amount of time and to honor people's busy schedules by ensuring the workshop ends on time. Transcriptions are made available in a published appendix and summarized in the roadmap deliverable itself.

Other important aspects of the workshops center on logistics. The workshops include morning and afternoon refreshments and a working lunch. Bringing-in snacks, coffee, tea, and lunch is a courtesy the project team happily offers volunteer participants. Doing so also minimizes disturbances and mitigates against the potential of losing participants who might otherwise step-out for extended periods. As another way to avoid distractions and keep participants as engaged as possible, the team prefers not to provide wireless Internet service.

The facilitator must also be an observant and proactive problem-solver to optimize the sub-groups' work. In every workshop there is likely to be a few people who try to serve as de-facto facilitator or "gate keeper." When this occurs the facilitator intervenes and requests that each member spend a few minutes on their own to populate posters for the rest of the group to build upon. Another tendency is for some sub-group members to "check out" due to disinterest or distraction. Immediate and respectful intervention has almost always resolved this. Finally, it is important that the facilitation support team serves as a conduit to relay questions and issues to the lead facilitator, but that the lead facilitator remains the participants' primary point of contact. This minimizes interruptions, helps ensure a consistent message, and decreases confusion caused by conflicting instructions from multiple facilitation team members.

### F. Workshop Facilitation Support

Over the years the team has developed some best practices fundamental in ensuring high-quality output. These serve as reminders to participants throughout the day and include:

- Fill-in workshop cards using complete sentences with legible handwriting.
- Avoid specialized acronyms—or, if they must be used, first spell them out.
- Avoid specialized jargon.
- Ensure that cards are appropriately linked to at least one card (more when appropriate) in the swim lane immediately above.
- Include the author's initials on the cards.
- The purpose is not to try to capture the entire universe of possibilities, but only the key items and linkages.
- Sub-group discussions are an essential part of this process, but be sure to record the key outcomes of these discussions on the posters.
- If important *non-technology* related gaps or needs arise (e.g., "We need better training."), then it does not belong

on a *technology* roadmap; instead, record these on the “parking lot” posters for documentation.

#### G. Identifying Participants and Optimizing Their Time

Roadmap content is only as good as the expertise it encapsulates and conveys, so the project team works diligently to populate workshops with a critical mass of participants and invites them both to develop roadmap content and help refine its structure.

The project team has applied three methods to identify potential workshop participants. They have used the TI Office’s lists of volunteers and interested parties. They have relied on the professional networks of project partners the Electric Power Research Institute (EPRI), the Northwest Energy Efficiency Alliance, and the Washington State University (WSU) Energy Program. They have also used social network analysis tools and methods [8, 18].<sup>4</sup>

The hands-on, proactive, facilitation style required to make a workshop successful requires there to be more than one member of the facilitation team for participant groups larger than about ten. Experience has also taught that sub-groups are generally most effective and productive when they contain between eight and twelve participants. Fewer than about eight participants risks not having important organizations or perspectives represented; many more than about twelve risks both having more people than can be accommodated in the room and more people than can effectively work together as a team.

The project team invites participants based on expertise in the sub-set of the “org chart” that Principals prioritized (the org chart is described in more detail in the Tools section that follows). Once in the workshop, the facilitator offers participants some creative control by presenting a draft list of sub-groups based on areas of expertise aligned with org chart categories, and then invites participants to self-select into another sub-group if their contributions would be more valuable elsewhere. Finalizing the sub-groups is part of the first workshop objective.

### III. TOOLS

In addition to the workshop structure, agenda, and other processes developed to create the agency’s Energy Efficiency Technology Roadmap, during subsequent roadmapping projects the team refined a set of tools tailored to their needs and reflecting their experience. These included:

- A framework to help structure the subject matter—the “Organizational chart.” This diagram helps describe the

“full universe” of technology areas and allows decision-makers to prioritize a sub-set that will comprise the project.

- Content structure. Roadmap diagrams are composed of “swim lanes” to link content into four complementary and integral sections.
- Workshop materials. Posters and cards collect participant input during the hands-on workshops. This content is transcribed, reviewed, and forms the core of the roadmap deliverable.
- Content Transcription and Review. Spreadsheet templates to transcribe workshop output and facilitate third-party content review.

#### A. Subject Matter Framework: The “Organizational Chart”

This organizational structure summarizes the core research areas and topics within the subject being roadmapped. The “org chart” is a nested set of functions, research areas, and individual roadmap topics within the respective business line. Like the roadmaps themselves, org charts are live, working documents. They help provide structure for the subject matter and frame the roadmapping process. They are also revised and refined to reflect the dynamic nature of their content and the input of stakeholders and subject matter experts as the project progresses. Recognizing that there may not always be clear delineations between topics, and that different groups of experts might categorize them differently (and as effectively), the project team nevertheless has found org charts highly useful in structuring the project and final deliverable. The team strives to strike a balance between presenting a defensible draft-in-progress at each workshop while also giving participants some creative control over roadmap content and structure. Fig. 1 provides an example of the org chart developed for the Demand Response Technology Roadmap project in 2014.

#### B. Content Structure: Roadmap Diagram

The structure that BPA TI Office currently uses in its roadmap diagrams is composed of four “swim lanes.” Workshop participants populate these swim lanes guided by the four focus questions provided in workshop agendas (specified above). In each swim lane are one or more linked elements. From top to bottom, these are:

- 1 Drivers: What are the reasons to change? Critical factors that constrain, enable, or otherwise influence organizational decisions, operations, and strategic plans, to include: existing or pending regulations and standards; market conditions and projections; consumer behavior and preferences; and organizational goals and culture, among others.

<sup>4</sup> Social network analyses are visual representations of community connections. Reflecting the specific needs of technology R&D within the electric utility industry, these communities are composed of researchers, professors, graduate students, entrepreneurs, and other technical specialists whose productivity and leading-edge contributions to the field can be tracked through publications, patents, and presentations. PSU students have done the work of applying SNAs to develop lists of subject matter experts and leading institutions of knowledge.

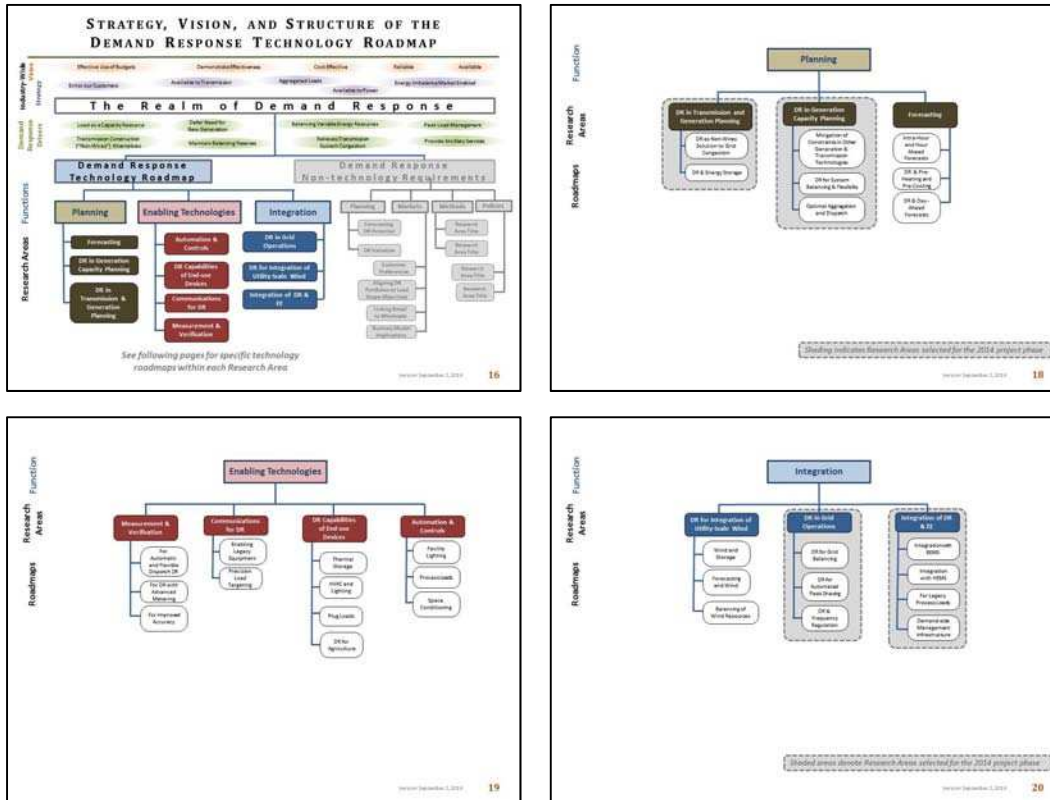


Figure 1. Organizational Chart.

- 2 **Capability Gaps:** What are barriers to change? Identify barriers or shortcomings that stand in the way of meeting Drivers.
- 3 **Technology Characteristics:** What technology solutions are needed to overcome barriers to change? Specific technical attributes of a product, model, system, etc., necessary to overcome Capability Gaps. To be included in the technology roadmap these will either be: Commercially Available but facing technical barriers needing to be addressed; or Commercially Unavailable and needing to be developed.
- 4 **R&D Programs:** What are the research programs to pursue to develop technology solutions? This involves the iterative process undertaken at universities, national laboratories, some businesses, and related organizations to generate new ideas, evaluate these ideas, and deliver the needed Technology Characteristics. This represents current and planned R&D intended to develop models and prototypes, evaluate these in laboratory settings, demonstrate them in the field, and conduct engineering and production analyses. The generic abbreviation “R&D” is to be understood as including, when appropriate, design, deployment, and demonstration in addition to research and development.

Prior to developing this approach, BPA TI staff experimented with a six-swim-lane structure. Experience showed that this added complexity both during workshops

and in presentation of the final documents. As part of the process of continual improvement, in early 2013 the Collaborative Transmission Technology Roadmap project team determined that while the extra content might offer some value, in the aggregate the additional complexity of six swim lanes did not outweigh the benefits offered by the more clear and concise four swim lane structure used in the Energy Efficiency Technology Roadmap since 2009. In 2013 the United Nations Framework Convention on Climate Change deemed this four-swim-lane approach a best practice in the way it clearly connected key organizational drivers with technology needs [10]. This structure can be seen in Fig. 2.

*C. Workshop Materials: Posters*

Posters developed for the hands-on roadmapping workshops echo the four swim lane diagram structure and are printed at 36” x 42” in size. There are two kinds of posters. Those produced for workshop 1 are composed of only the Drivers and Capability Gaps swim lanes. If the roadmap being developed is completely new, workshop 1 posters will have blank swim lanes; if it is being revised, the posters will likely have one or more Driver or Capability Gaps already identified, so the corresponding swim lane will contain content in the form of pre-printed cards. Workshop 2 posters contain all four swim lanes and also have the transcribed cards produced in workshop 1 printed in the Driver and Capability Gaps swim lanes on the corresponding poster. Examples of these posters can be seen in Fig. 3 and Fig. 4.

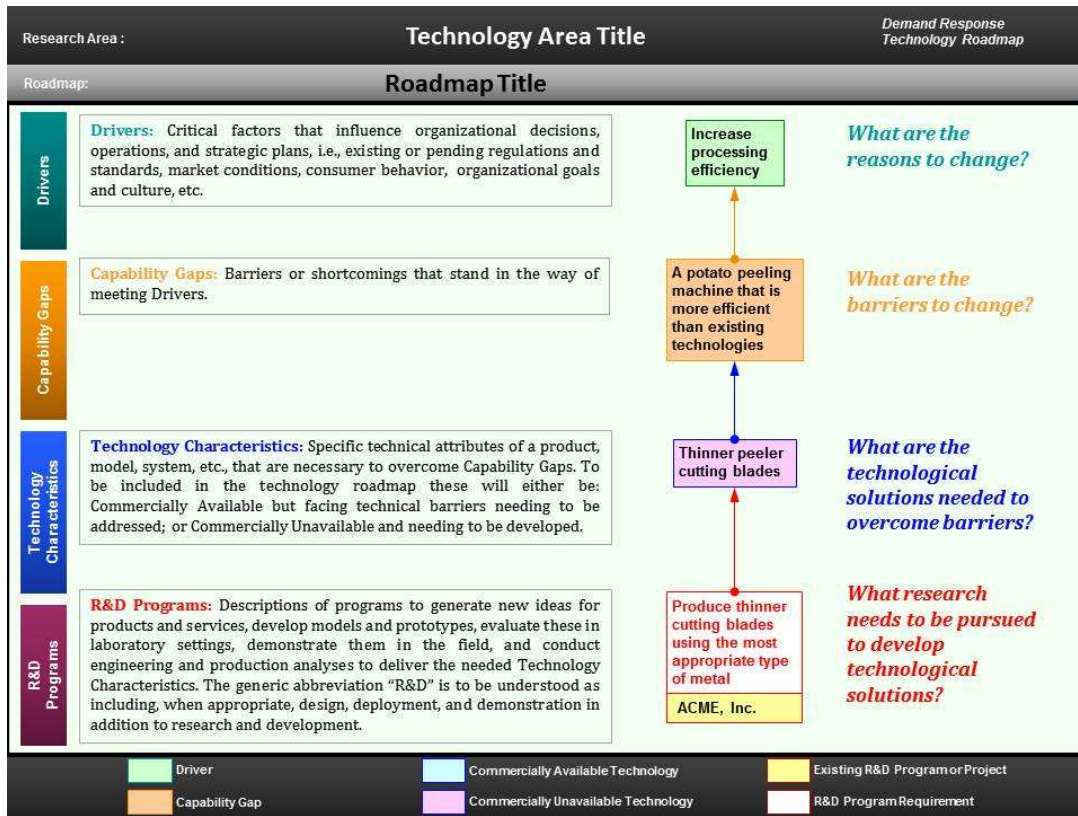


Figure 2. Roadmap diagram.

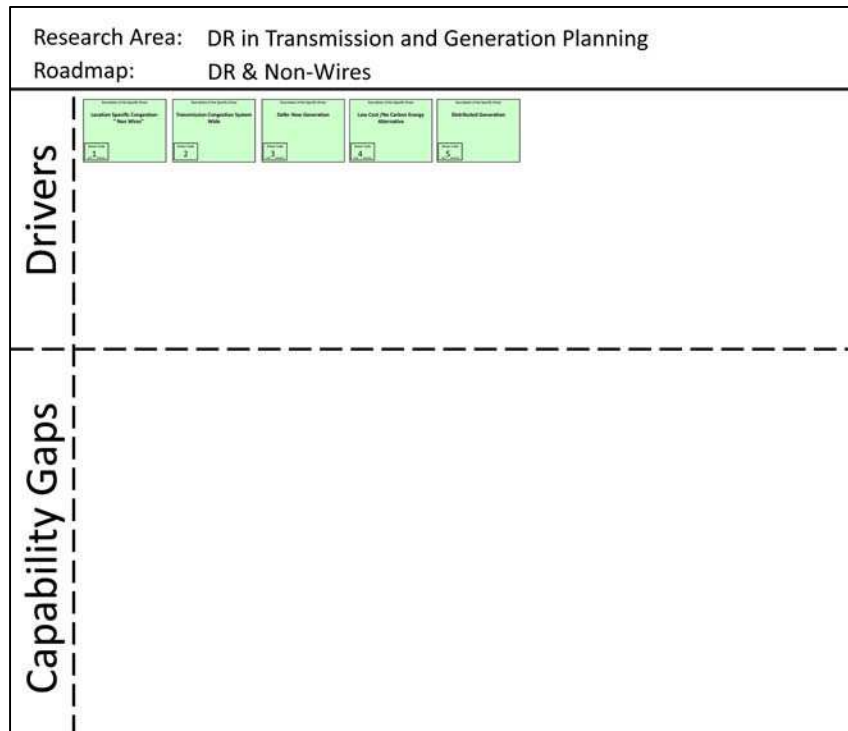


Figure 3. Workshop 1 poster.



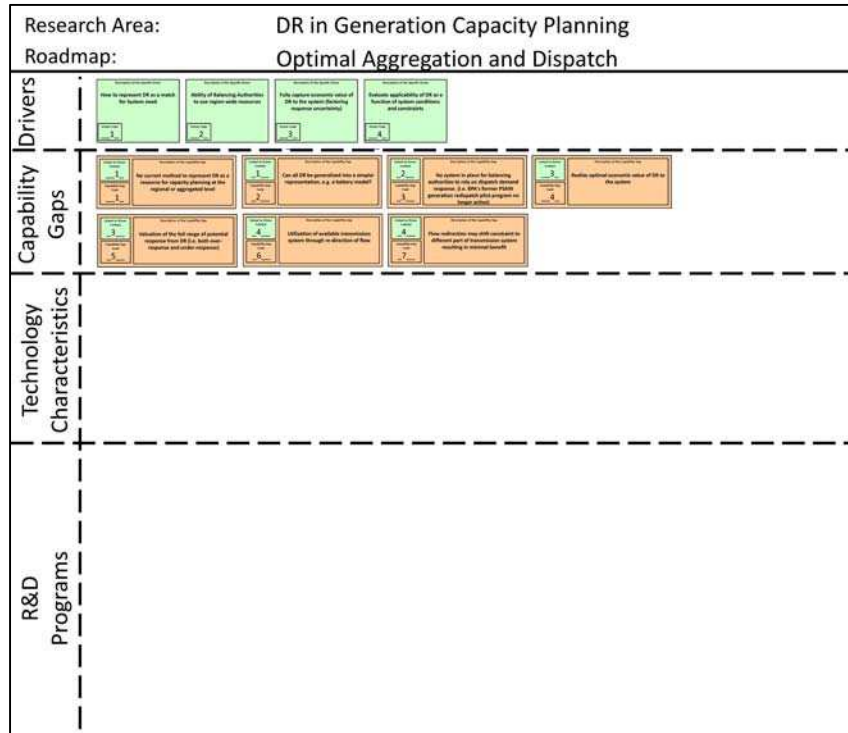


Figure 4. Workshop 2 poster.

D. Workshop Materials: Cards

Out of necessity, the project team moved away from using self-adhesive colored notepad paper to populate workshop posters. They replaced these with tailored color-coded cards on heavier card stock. These guide workshop participants while also ensuring that content intended for each swim lane is readily identified in the midst of the busy workshops. Standardizing these cards also helps streamline facilitation, content transcription, and deliverable production.

There are four different kinds of cards color-coded based on their corresponding swim lane. Each has been developed to capture the required information clearly and concisely. They share two common sections: one for authors’ initials and another for the facilitation team to assign sequential numbers essential in linking these cards. The unique features of these cards can be seen in Figs. Figure 5, Figure 6, Figure 7, and Figure 8.

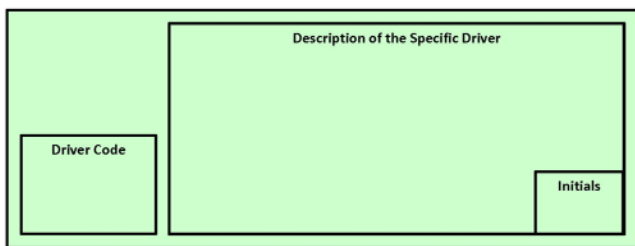


Figure 5. Driver card.

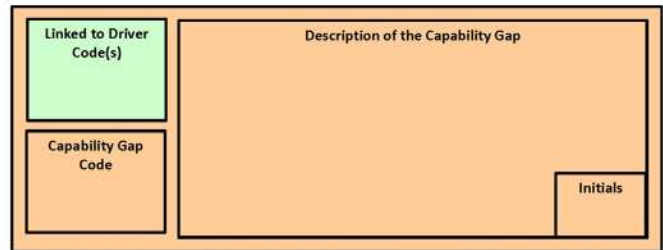


Figure 6. Capability Gap card.

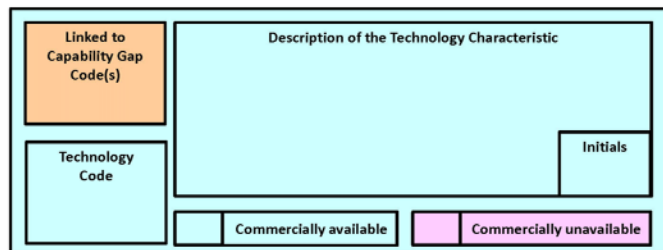


Figure 7. Technology Characteristic card.

Link(s) to Technology Characteristic(s)	Initials
R&D program title (limit to no more than 50 characters)	
R&D program summary (2-4 sentences summarizing purpose, scope, and goals)	
Key Research Questions	
<ol style="list-style-type: none"> <li>1.</li> <li>2.</li> <li>3.</li> <li>4.</li> <li>5.</li> <li>6.</li> </ol>	
If more room is needed please continue on the back of this page	
Existing Research	

Figure 8. R&D Program Description card.

#### E. Content Transcription and Review

Third-party review of roadmap content is important because it contributes another layer of refinement to content produced in the workshops. At its most basic level, it provides for fact-checking and correction of spelling and transcription errors. It also provides an opportunity for an independent set of subject matter experts to validate and clarify the content, much as the peer review process does in academic publishing.

Through trial and improvement, PSU students developed a spreadsheet template that standardizes the review process. It is designed to be effective whether or not the reviewer has had previous experience with this process. Color-coded rows correspond with each swim lane and columns correlate to workshop data: description, linkages, and participant initials. Third-party experts are asked to review this content, recommend changes or outright deletion, and provide any explanatory comments.

### IV. PARTNERSHIPS

#### A. Project Team

With experience accumulated since 2005 creating technology roadmaps for energy efficiency, transmission, demand response, and power generation, the BPA project team has a clear understanding of the kinds of expertise that a successful team requires. This experience has also clarified some of the key external partnerships necessary for success.

Expertise needed within the project team includes project management; planning and logistics; technology roadmapping theory & process; facilitation; post-workshop data review; and post-publication maintenance, collaboration, and communication. With BPA's TI Office taking the lead in managing roadmap projects, PSU providing academic rigor and support, and key external parties providing other kinds of assistance, these areas of expertise have tended to fall into three complementary categories.

BPA staff provide program and project management; develop most of the workshop materials (such as slide presentations, reference handouts, and all complementary and supplemental documents); oversee logistics (including printing all workshop materials, scheduling the workshop venue, and arranging for food and refreshments); manage invitations; facilitate workshops; produce final deliverables; and coordinate post-publication outreach. Another category of BPA staff contributions come from the technical and operational subject matter experts who become part of the team for specific projects. For example, during the Collaborative Transmission Technology Roadmap project in 2013, a representative from BPA's Transmission Engineering and Technical Services group joined the team. His strong skills in project management, deep technical background, and extensive professional contacts complemented well the skill set of the TI Office and PSU teams and helped ensure project success. In 2014, subject matter experts from BPA's Demand Response and Power Generation and Asset Management groups contributed greatly to those respective projects.

PSU faculty and students provide academic rigor, prepare workshop posters, support workshop facilitation, transcribe workshop output, and transfer raw transcriptions into roadmap diagrams for the final deliverables. During workshops, PSU students support the lead facilitator by providing active quality control (e.g., ensuring participants populate posters and cards completely and properly). Diligence of this kind greatly aids in the post-workshop transcription process and saves significant time and effort in the long run.

External parties' contributions depend on their area of expertise and level of involvement. One critical kind of contribution is third-party review of workshop transcriptions. This generally occurs in two stages: between workshops 1 and 2 and then after workshop 2 prior to creation of the draft roadmap deliverable. This review includes fact checking, correcting grammar and spelling errors, and confirming linkages. Staff from the WSU Energy Program and EPRI have served in this role.

External parties have also provided workshop facilitation support, helped generate leads for workshop participants, managed invitations, and helped arrange workshop venues and manage logistics.

#### B. Contributors

No matter how well the project is planned and implemented, however, team members recognize they would

not generate quality content without identifying and convening the right mix of international experts from utilities, industry, research institutions, and other groups. What constitutes “the right mix” is contingent upon the roadmap topic and need. Nevertheless, the team has arrived at some general guidelines.

First and most obvious, it is important to invite those with strong expertise in the topic. Second, especially when drawing on outside expertise, the best content comes from sub-groups made up of a representative mixture of the key participant types: utilities, academia, national laboratories, vendors/manufacturers, government, non-governmental organizations, and non-profits. Third, while “strategic” experts should predominate workshop 1 and “tactical” experts workshop 2, it is also helpful to have a few workshop 1 participants attend workshop 2 to help provide a bridge between these two groups. Finally, it is most effective to invite participants as early as possible to ensure their availability; four months or more advance notice is ideal.

### V. APPLICATION OF ROADMAPS AT BPA

Roadmaps are an integral element in the BPA TI Office’s technology management framework. This framework includes an annual cycle of “Production” (December into July) and “Introversion” (July into December) [1]. During the former period R&D projects are actively added and removed from the portfolio; the latter period allows staff to revisit and refine work done to date, implement enhancements, and prepare for the next production phase. The framework also includes portfolio management guidance from an internal cross-agency council and the development and strengthening of strategic external partnerships.

The TI Office’s annual R&D funding cycle begins with a review of current projects in late January and early February to decide if the projects are delivering expected value and will continue to be funded. Stage gates established for each project trigger these decisions. From March to May the TI Office manages a solicitation process for new projects that will commence the following fiscal year (which begins in October). Roadmaps play a central role in this solicitation process. Both internal and external respondents are instructed to articulate clearly in their proposal which page(s) of the applicable roadmap their project would address. With this information, proposals undergo technical review in June, and final decisions come in July.

Year-to-year, development of BPA’s R&D portfolio is driven by the Technology Confirmation and Innovation Council (TC/I Council). This group of executives and experts is comprised mostly of internal agency staff but also includes invited external guest members. TC/I Council members evaluate the current portfolio each January, agree upon the sections of agency roadmaps that will be open to proposals during the March-May solicitation period, and decide upon the next fiscal year’s portfolio in July [1].

Thus, roadmaps serve to distill expertise from international subject matter experts in response to business challenges and opportunities of importance to the agency; convey this information to the agency’s TC/I Council to help guide them in making strategic R&D planning decisions; and, as part of the TI Office’s annual solicitation cycle, convey research needs to the broadest possible community of researchers to solicit project proposals with the potential to help BPA continue to provide safe, reliable and cost-effective power.

BPA’s four “swim lane” roadmap structure allows for “top-down” and “bottom-up” communication. It also facilitates communication both to internal and external audiences.

- 1 Top-down: Executives and senior managers who are likely to be more interested in business opportunities and challenges and barriers that stand in the way of meeting these can read down the diagram to learn something about potential technological solutions.
- 2 Bottom-up: Researchers and technical subject matter experts can read up the diagram to learn about specific research questions and technology characteristics that might help deliver solutions to pressing needs, and then formulate research proposals to fulfill these needs.
- 3 Internal: Executives, managers, and staff can use this structure to ensure that their needs are aligned and documented prior to being made available to external parties as part of the TI Office’s annual solicitation.
- 4 External: University faculty, national laboratory staff, vendors, and others in the research community can learn about how their work might help address utility industry needs. This knowledge increases the likelihood of receiving higher-quality proposals during the TI Office’s annual solicitations. It also offers the potential to expand BPA’s partnerships in the research community based on topics of interest articulated in roadmaps.

### VI. OPPORTUNITIES FOR CONTINUED REFINEMENT

The experience gained in planning and implementing successful roadmapping projects and the central role that roadmaps play in BPA’s strategic approach to technology R&D planning illuminates opportunities to expand and improve upon what the agency and its partners have accomplished. There are at least four opportunities:

- Develop Cross-Agency “Focus Areas.” Look across the agency’s technology roadmaps—Energy Efficiency, Transmission, Demand Response, and Power Generation and Asset Management—to identify common business challenges, opportunities, barriers, and gaps. From these common topics and themes will likely emerge suggestions where particular R&D projects could help address needs shared by multiple groups in the agency. The TI Office refers to these areas of cross-agency applicability as “Focus Areas.”

- Enhancing Data Management, Quality Control, and Usability. Creating, maintaining, and publishing roadmap content is accomplished using a widely-available suite of spreadsheet, presentation, and word processing software, with the final deliverables converted to Portable Document Format (PDF) files. Any changes to the deliverable must follow a time- and labor-intensive process. Recent advances in data management and visualization tools by a number of international software developers offer the potential to decrease significantly the time currently spent maintaining and publishing BPA's technology roadmaps, while concurrently improving quality control and usability.
- Prioritization. To help guide agency R&D investment decisions, the project team has attempted a few methods of prioritizing roadmap content. One of the lessons-learned from this experience is that an agency- or region-specific approach to prioritization is likely to be the most effective option to in achieve the agency's goals of collaborative relationships, trustworthy stewardship, and operational excellence. This experience has helped inform a project that BPA and PSU will collaborate on in the near future.
- Integration of Roadmap Content Management within Agency Business Lines. Identifying cross-agency "Focus Areas," enhancing content management and usability, and establishing a robust prioritization methodology should help advance the TI Office's technology management approach by empowering internal "owners" of roadmap sections. This will provide a point-of-contact within the group generally responsible for the roadmap content area who can serve as an advocate and help co-lead projects to expand or update roadmaps.

## VII. CONCLUSION

Since 2005, the BPA TI Office has had success developing and refining a tailored approach to roadmapping as one of the many technology management tools, processes, and methods applied for agency and regional benefit. In this, the agency has been at the forefront of utilities in North America. Recognizing that tools, processes, and methods must always evolve to account for constant industry changes, TI Office staff welcome every opportunity to share their experience, receive feedback, and continue to improve.

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