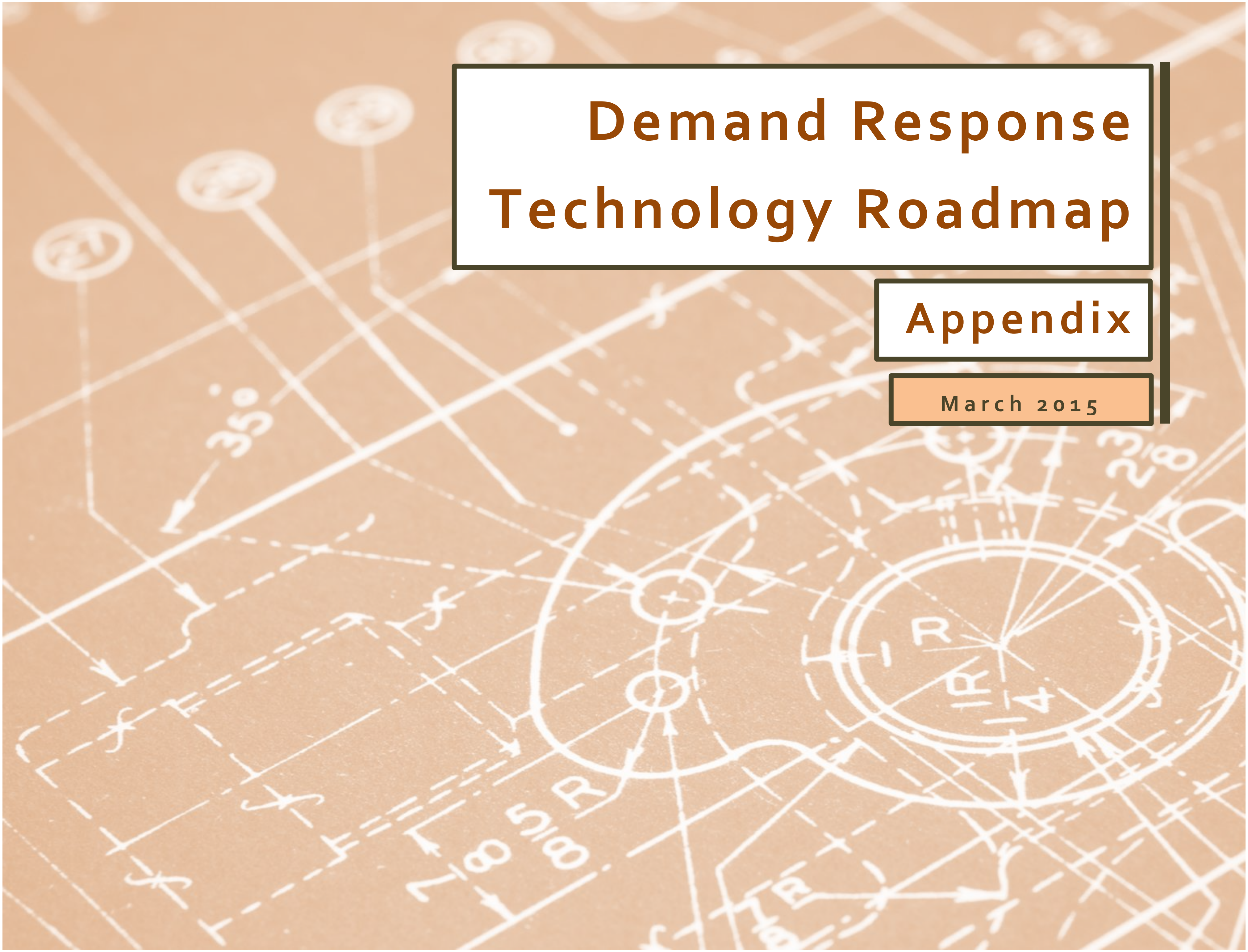


Demand Response Technology Roadmap

Appendix

March 2015

Enhanced PDF Functionality

Functionality of the PDF version of this document has been enhanced in the following ways:

- **Embedded Table of Contents Links:** The Table of Contents has been linked to the appropriate sections of the document.
- **Internal links embedded within the document** to facilitate navigation between sections and "Back to Table of Contents."
- **Control + F:** As always, one can navigate through the document by searching for specific words or phrases by pressing the "Control" and "F" keys simultaneously.

Table of Contents

Introduction

This appendix contains process documents and related files that pertain to the meetings and workshops convened to develop content for the Demand Response Technology Roadmap. The project team has developed this companion document in the interest of providing full visibility into the various roadmapping workshop agendas, presentation materials, and transcripts.

For the background to the Demand Response Technology Roadmap and to make use of individual roadmaps, the reader is invited to review the most recent version of the document available at the Bonneville Power Administration Technology Innovation Office website (www.bpa.gov/ti). This website also features links to other agency technology roadmaps—in Energy Efficiency, Transmission, and Power Generation Asset Management—as well as information about the agency's annual funding opportunity announcements.

For more information about the Demand Response Technology Roadmap or to offer revision suggestions, contact:

James V. Hillegas-Elting
Technology Roadmapping Project Manager
Bonneville Power Administration
jvhillegas@bpa.gov, 503.230.5327

Appendix 1: Project Team

BPA Demand Response Executive Sponsor Team

Mark Gendron, Senior Vice President, Power Services

Richard Shaheen, Senior Vice President, Transmission Services

Cathy Ehli, Executive Vice President, Corporate Strategy

Suzanne Cooper, Vice President, Bulk Marketing

Richard Génecé, Vice President, Energy Efficiency

Robert King, Vice President, Transmission Marketing and Sales (Acting)

Larry Kitchen, Director, Long Term Sales and Purchases

BPA Project Sponsor Team

Terry Oliver, Chief Technology Innovation Officer

Kim Thompson, Energy Efficiency Implementation Director / Demand Response Program Manager (Acting)

Ryan Fedie, Manager, Energy Efficiency Engineering Services

Project Implementation Team

Project Manager & Workshop Facilitation

James V. Hillegas-Elting, Bonneville Power Administration

Demand Response Subject Matter Expert

Thor Hinckley, Bonneville Power Administration

Strategy Consultant

Tugrul Daim, Portland State University Engineering and Technology Management Department

Facilitation, Logistics, & Other Support

Bonneville Power Administration: Judith Estep, Jim Bowen, Jisun Kim

Portland State University Engineering and Technology Management Department: Edwin Garces, Fahad Aldhaban, Kevin van Blommestein, Yonghee (Joseph) Cho, Momtaj Khanam, João Lavoie, Chih-Jen Yu

Transcription, Fact Checking, & Technical Content Review

Portland State University Engineering and Technology Management Department: Yonghee (Joseph) Cho, Edwin Garces, Kevin van Blommestein

Electric Power Research Institute: Omar Siddiqui, Ammi Amarnath, Angela Chuang, Ram Narayanamurthy, Aidan Tuohy

Document Production

Editor, Lead Author, and Design: James V. Hillegas-Elting

Content Contributors: Tugrul Daim, Judith Estep, Thor Hinckley

Appendix 2: Contributors

Workshop Participants

Workshop 1, June 13, 2014

Demand Response in Grid Operations

1. Tom Brim, Bonneville Power Administration
2. Angela Chuang, Electric Power Research Institute
3. Pete Pengilly, Idaho Power Company

Integration of Demand Response and Energy Efficiency

4. Ryan Fedie, Bonneville Power Administration
5. Richard Génecé, Bonneville Power Administration
6. Jeff Harris, Northwest Energy Efficiency Alliance
7. Jess Kincaid, Oregon Department of Energy
8. Jenny Roehm, Advanced Load Control Alliance

Measurement and Verification

9. Ammi Amarnath, Electric Power Research Institute
10. Ken Dragoon, Ecofys
11. Will Price, Eugene Water & Electric Board

Demand Response in Transmission and Generation Planning

12. Sarah Arison, Bonneville Power Administration
13. Diane Broad, Oregon Department of Energy
14. Debbie Hammack, Bonneville Power Administration
15. Omar Siddiqui, Electric Power Research Institute
16. Don Watkins, Bonneville Power Administration
17. Nita Zimmerman, Bonneville Power Administration

Demand Response in Generator Capacity Planning

18. Lee Hall, Bonneville Power Administration
19. Ben Kujala, Northwest Power and Conservation Council
20. Jeff Newby, Bonneville Power Administration

Workshop 2, Sep. 18-19, 2014

Demand Response in Grid Operations

1. Farrokh Albuyeh, Open Access Technology Int'l, Inc.
2. Tom Brim, Bonneville Power Administration
3. Kwok Cheung, Alstom Grid
4. Angela Chuang, Electric Power Research Institute
5. Ifty Hasan, Entouch Controls
6. Karanjit Kalsi, Pacific Northwest Nat'l Laboratory
7. Sila Kiliccote, Lawrence Berkeley Nat'l Laboratory
8. Steven Low, California Institute of Technology
9. Ning Lu, North Carolina State University
10. Kaj Skov Nielsen, Siemens
11. Alex Papalexpolus, ECCO International
12. Anurag Srivastava, Washington State University
13. Jianhui Wang, Argonne Nat'l Laboratory
14. Le Xie, Texas A & M University

Integration of Demand Response and Energy Efficiency

15. Chen Chen, Argonne Nat'l Laboratory
16. Ryan Fedie, Bonneville Power Administration
17. Carl Linvill, Regulatory Assistance Project
18. Ebony Mayhorn, Pacific Northwest Nat'l Laboratory
19. Ram Narayanamurthy, Electric Power Research Institute
20. Mary Ann Piette, Lawrence Berkeley Nat'l Laboratory
21. Manisa Pipattanasomporn, Virginia Tech
22. Jill Powers, California Independent System Operator
23. Farrokh Rahimi, Open Access Technology Int'l, Inc.
24. Alison Silverstein, N. American Synchrophasor Initiative
25. Megan Stratman, Northwest Requirements Utilities
26. Heather Williams, Opower

Demand Response in Transmission and Generation Planning

27. Diane Broad, Oregon Department of Energy
28. Frank Brown, Bonneville Power Administration
29. Anders Johnson, Bonneville Power Administration
30. John Wang, ABB
31. Rob Pratt, Pacific Northwest National Laboratory
32. Aidan Tuohy, Electric Power Research Institute

Demand Response in Generator Capacity Planning

33. Shawn Chandler, Bonneville Power Administration
34. Erik Gilbert, Navigant
35. John Goodin, California Independent System Operator
36. Ben Kujala, Northwest Power and Conservation Council
37. Tom Osterhus, Integral Analytics
38. Omar Siddiqui, Electric Power Research Institute

APPENDIX 3: PRINCIPALS' MEETING (MAY 15, 2014)

Demand Response Technology Roadmap Project

DR Executive Sponsor Team Meeting Agenda

May 15, 2014 ~ 11:00–12:00

Objectives

1) Review the project's purpose, scope, and timeline;
2) Determine 3-5 priority Research Areas comprising the CY 2014 project phase; and
3) Identify next steps.

11:00-11:05	Opening Remarks & Introductions [Thor Hinckley]
Objective 1: Review the pilot project's purpose, scope, and timeline	
11:05-11:15	Project Outline: ▪ Technology roadmapping at BPA [Terry Oliver] ▪ Timeline, tasks, & deliverables [Thor Hinckley] ▪ Roadmap organizational chart [Thor Hinckley]
Objective 2: Determine 3–5 priority Research Areas comprising the FY 2014 project phase	
11:15-11:20	Review pre-work survey results & DR Team recommended priorities [Thor Hinckley]
11:20-11:55	Facilitated discussion of survey results leading to a consensus on priorities [All]
Objective 3: Identify next steps	
11:55-12:00	Next steps [Thor Hinckley]: ▪ Workshop 1 draft participant list

Demand Response Technology Roadmap

Project Summary

Version 2, April 16, 2014

Objective: Develop a Demand Response (DR) Technology Roadmap that applies best practices and documents the subject matter expertise of key agency staff and regional partners to:

1) provide a stand-alone road map that supplements the *National Energy Efficiency Technology Roadmap Portfolio* by adding or refining content specific to DR (i.e., dispatchability and other ancillary services);
2) complement the agency's strategic approach to DR articulated in such documents as the DR Business Case, Energy Efficiency Strategic Plan, Commercial Operations Current State Assessment, and long-term agency strategy currently in development; and
3) help guide the BPA Technology Innovation Office's investment in DR-related research, development, and demonstration projects.

Core Project Team: BPA and the Portland State University Engineering and Technology Management Department; representatives from the Electric Power Research Institute will also be contributing to the project in roles to be determined.

Schedule: May–November, 2014.

Roadmap Structure: Key agency opportunities and challenges will be linked to specific technology R&D needs using a structure similar to the *National Energy Efficiency Technology Roadmap Portfolio* and the Collaborative Transmission Technology Roadmap based on 4 "swim lanes":

1) <u>Drivers:</u> Opportunities and challenges facing the agency and region.
2) <u>Capability Gaps:</u> Barriers in the way of responding effectively to Drivers.
3) <u>Technology Characteristics:</u> Aspects of a product or service needed to overcome Capability Gaps.
4) <u>R&D Programs:</u> Research descriptions and key questions to develop the needed Technology Characteristics and, where appropriate, identify research projects currently underway.

Face-to-Face Meetings to Collect Roadmap Information:

DR Executive Sponsor Meeting (duration: 1 hour)	**May 15, 2014, Portland.** **Objective:** Come to consensus on priority Research Areas on which to focus the FY 2014 project phase.
Workshop 1 (duration: 1.5 Days)	**June 12–13, 2014, Portland.** **Objective:** Identify Drivers and Capability Gaps in the prioritized Research Areas. **Participants:** Senior-level managers from BPA, key regional stakeholders, and EPRI with strategic expertise such as policy development, regulatory compliance, business development, etc.
Workshop 2 (duration: 1.5 Days)	**September 18–19, 2014, Portland.** **Objective:** Identify Technology Characteristics and R&D Programs in the prioritized Research Areas. **Participants:** Technical staff and subject matter experts from BPA, regional stakeholder organizations, EPRI, National Labs, DOE, Universities, etc.

Deliverable: A Demand Response Technology Roadmap based on the priority Research Areas determined by the BPA DR Executive Sponsor Team will be delivered to stakeholders in November 2014.

Back to Table of Contents

Demand Response Technology Roadmap Project

Pre-work Survey, DR Executive Sponsor Team Meeting, May 15, 2014

version April 25, 2014

Your response to this survey will allow the project team to create a first draft of the DR Executive Sponsor Team's priority DR Research Areas. This draft prioritization will then inform the discussion to be held during the May 15 DR Executive Sponsor Meeting. The outcome of this meeting will be to finalize the scope of the DR Technology Roadmap project that will continue through FY 2014; the project team will deliver the roadmap to the BPA Technology Innovation Office in November 2014 in preparation for the March 2015 Funding Opportunity Announcement.

***Each Executive:* Please attach the completed survey as an MS Word document to an email and send to James Hillegas-Elting (jvhillegas@bpa.gov) by close of business May 12, 2014.**

Survey Objective

This survey is being conducted in preparation for the May 15 DR Executive Sponsor Team meeting, during which a prioritized list of Research Areas will be finalized (see the meeting agenda attached). Since this phase of the DR Technology Roadmap project will focus on a subset of technologies, your input is needed to determine the Research Areas of greatest strategic importance for BPA.

We request each Executive refer to the table below and to vote on the Research Areas listed—*one survey document for each Executive*. As the Meeting agenda shows,

1. The project team will consolidate all responses before the meeting and report the results.
2. Each Executive will be allowed time to highlight their priorities as a way to kick-start a discussion that will lead to a consensus set of Research Areas for the project.

Technology Areas and Your Organization's Voting

The project team prepared the following preliminary list primarily by referring to BPA and EPRI sources. The Research Areas encompass broad-based categories grouped according to three Function categories: Planning, Enabling Technologies, and Integration.

A *Research Area* is a related set of devices, algorithms, equipment, tools, techniques, services, etc., that collectively encompass a core business function and/or operational need. For example, "DR in Transmission and Generation Planning" is a core element of the "Planning" Function.

Action Requested by May 12, 2014: You have 6 votes to divide among the 10 Research Areas defined below. The list is intended to be comprehensive, but respondents are welcome to add any missing Research Areas or roadmaps. Any particular Research Area may receive more than 1 vote, but the total number of votes per organization is not to exceed 6.

DRAFT Technology Areas	**Votes** *(Not to exceed **6** total for the entire survey)*
Function: Planning — **Technologies that facilitate, support, streamline, and otherwise enable and enhance transmission and generation planning**	
A. DR in Transmission & Generation Planning: Technologies used in planning processes to address existing and forecast transmission and generation needs. These technologies assist grid operators in load management and enable improved system reliability and provide imbalance reserves. These technologies while providing improved system flexibility may also enable participation in energy imbalance markets.	
B. DR in Generation Capacity Planning: Technologies used in the generation capacity planning process to address BPA capacity needs. These technologies address hydro-generation imbalance and may provide BPA grid operators with other ancillary services.	
C. Forecasting: Technologies involved with developing forecasts for day-ahead, hourly and sub-hourly system loads as well as balancing requirements for capacity. Examples include technologies that assist in pre-chilling and pre-heating for thermal storage. This includes technologies that assist in predictive control of DR assets as well as providing improved responsiveness to month-ahead, day-ahead, hour-ahead notification periods.	
Function: Enabling Technologies — **Technologies that enable demand response communication, controls, scheduling, confirmation, billing, and related activities**	
D. Automation and Control: Technologies with the ability to dynamically respond to signals from the grid or grid operators to control loads (INCs or DECs). This includes DR enabled devices capable of responding to sub-hourly notification and devices that provide for automatic economic dispatch. These technologies increase customer engagement and provide reliable load reductions.	
E. Communications for DR: Technologies and software protocols (BPA requires OPEN ADR2.0b) used to trigger, respond to and measure DR events. These technologies enable load augmentation in response to peak demands including technologies that are smart meter enabled. Utilizing two-way communications these technologies enable assets to provide additional capacity. These devices provide for cyber-secure economic dispatch and can facilitate participation in energy imbalance markets.	
F. DR Capability of End Use Devices: Technologies that respond to dynamic signals from the grid or grid operators to control loads (INCs or DECs). Examples of these technologies include DR enabled automatic lighting controls, automated thermostats as well as devices for both electrical and thermal energy storage.	
G. Measurement and Verification: Technologies and protocols (using the OPEN ADR 2.0b framework) to measure and verify load increases or decreases (INC/DEC) dispatched during a DR event, in comparison with an established energy use baseline at a site or aggregation of sites. Examples include technologies that provide measurement and verification of DR events as well as in event participation rates. This also includes devices to assist in accurate DR event settlements..	

Function: Integration	Technologies that enable the integration of other components, systems, software, generation assets to facilitate demand response
H. DR in Grid Operations: Technologies that can enable demand response in response to load forecasts or dynamic grid energy or capacity requirements. These technologies allow system operators to respond to generation imbalances and result in increased system flexibility. These technologies which may typically involve a DR management system are also useful for grid regulation.	
I. DR for Integration of Utility-Scale Wind: Technologies to address hydro-generation imbalances associated with oversupply of wind energy—such as generation oversupply and intermittent generation—and provide grid regulation services that assist in wind integration.	
J. Integration of DR and EE: Technologies used at a site or group of sites to maximize energy efficiency and enable demand response. Examples include integrated home and business energy management systems that enable DR and provide a real-time determination of available capacity, as well as automatic lighting controls, automated thermostats, and plug load controls.	
Other Suggestions	

Demand Response Technology Roadmap

Demand Response Executive Sponsor Team Meeting

Portland, OR
May 15, 2014

FINAL May 15, 2014

Objectives

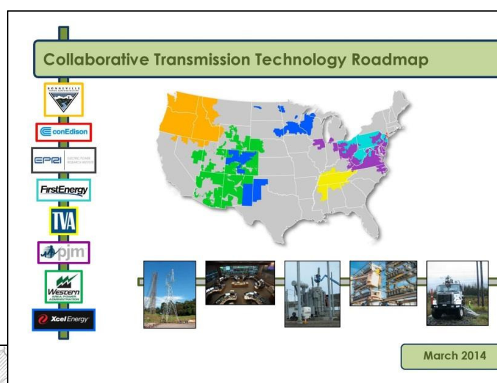
1) Review the project's purpose, scope, and timeline;
2) Determine 3-5 priority technology areas that will comprise the CY 2014 project phase; and
3) Identify next steps.

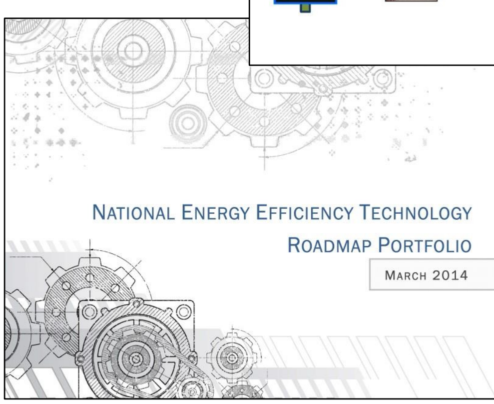
Back to Table of Contents

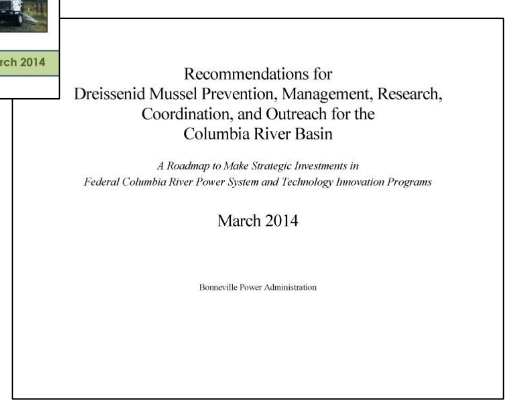
Agenda

11:00-11:05	Opening Remarks & Introductions [Thor Hinckley]
Objective 1: Review the project's purpose, scope, and timeline	
11:05-11:15	Project Outline: ▪ Technology roadmapping at BPA [Terry Oliver] ▪ Timeline, tasks, & deliverables [Thor Hinckley] ▪ Roadmap organizational chart [Thor Hinckley]
Objective 2: Determine 3–5 priority Research Areas comprising the CY 2014 phase	
11:15-11:20	Review pre-work survey results & DR Team recommended priorities [Thor Hinckley]
11:20-11:55	Facilitated discussion of survey results leading to a consensus on priorities [All]
Objective 3: Identify next steps	
11:55-12:00	Next steps [Thor Hinckley]

Technology Roadmapping at BPA





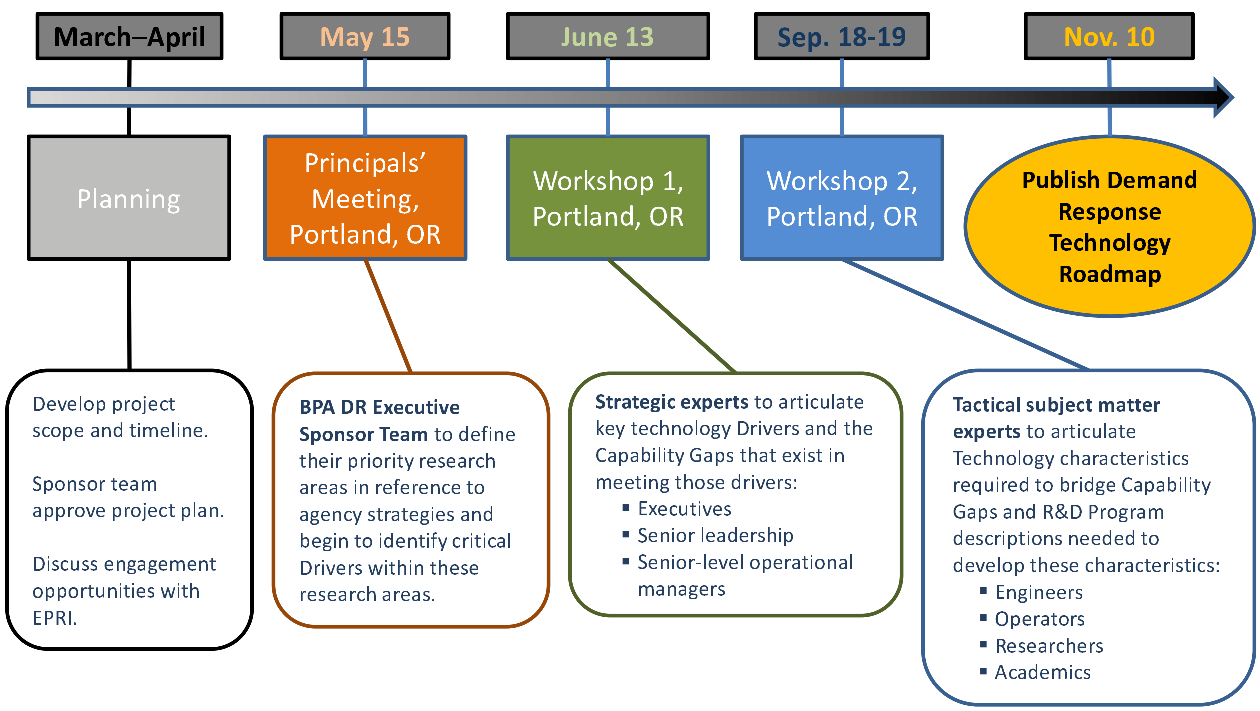


Roadmap Structure

Drivers	**Drivers:** Critical factors that influence organizational decisions, operations, and strategic plans, i.e., existing or pending regulations and standards, market conditions, consumer behavior, organizational goals and culture, etc.	*What are the reasons to change?*
Capability Gaps	**Capability Gaps:** Barriers or shortcomings that stand in the way of meeting Drivers.	*What are the barriers to change?*
Technology Characteristics	**Technology Characteristics:** Specific technical attributes of a product, model, system, service, etc., that are necessary to overcome Capability Gaps.	*What are the technological solutions needed to overcome barriers?*
R&D Programs	**R&D Programs:** Current and planned research, development, and demonstration programs to deliver the needed Technology Characteristics, undertaken at utilities, universities, national laboratories, and vendors.	*What research needs to be pursued to develop technological solutions?*

Timeline

March – November 2014



Back to Table of Contents

"Organizational Chart"

Purpose:

This organizational structure is offered as one way to present, in summary form, the **core research areas and topics within demand response**. It is intended as a live, working document to help provide structure for the technology roadmapping process; it is subject to revision and refinement to reflect the dynamic nature of demand response and the input of stakeholders and subject matter experts.

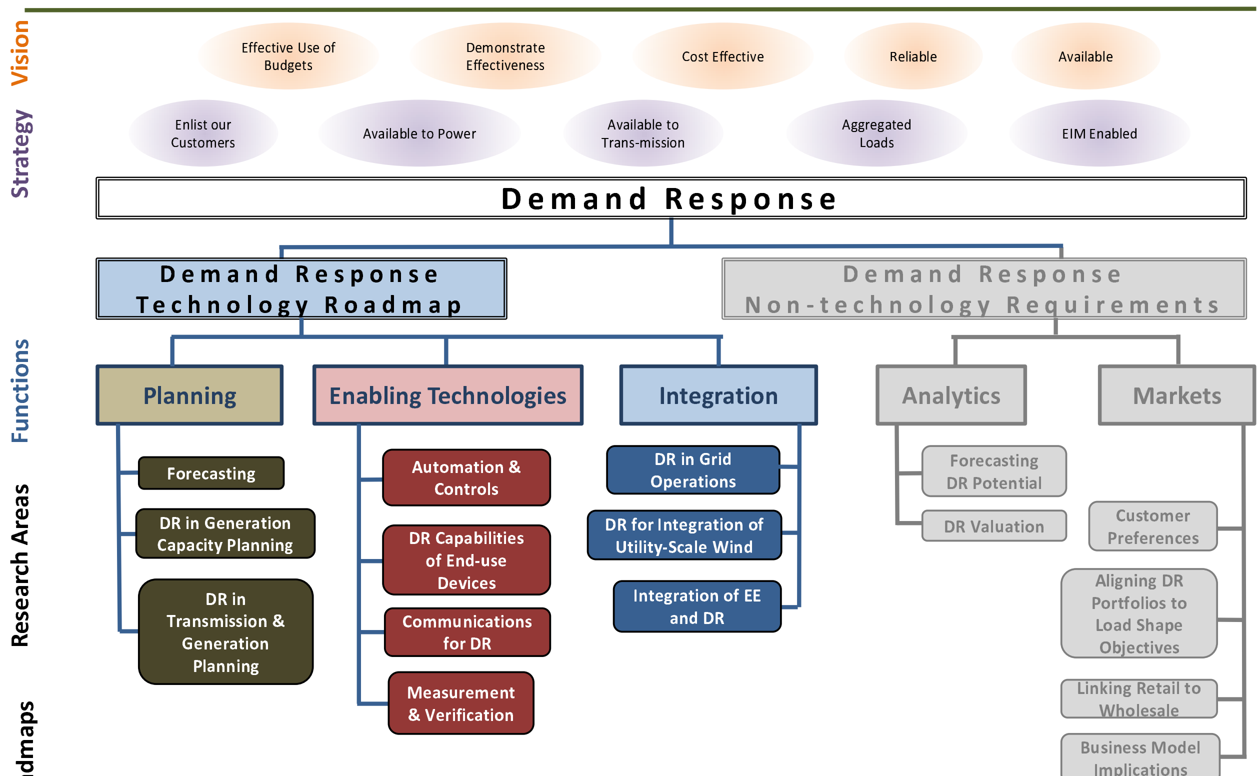
Assumptions:

Under each "Research Area" there will be one or more technology roadmaps. Thus, within the "Enabling Technologies" Function there are four Research Areas, and each of these Research Areas will be composed of one or more Roadmaps.

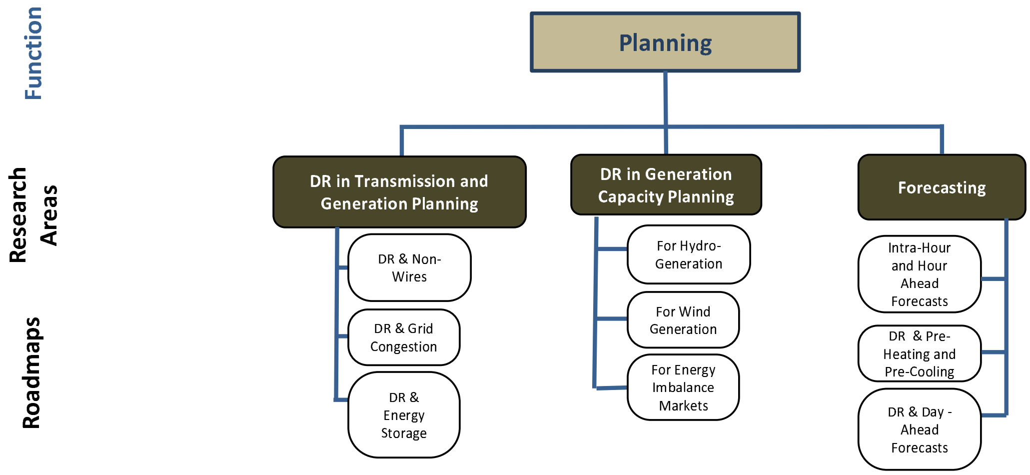
Authors:

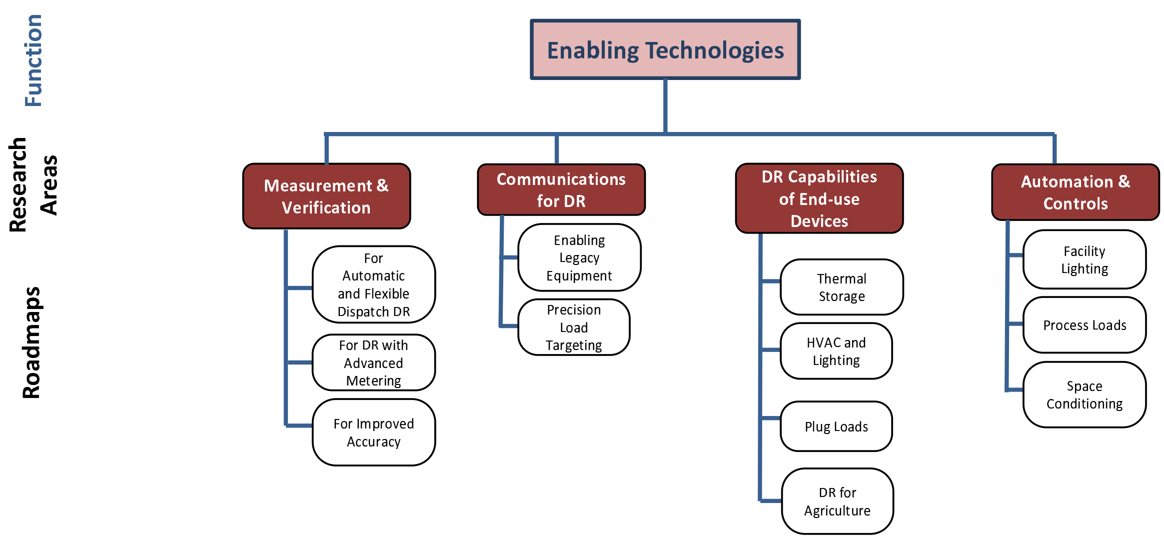
Developed based on BPA DR Team needs with input from the in-process EPRI DR Roadmapping project (led by Omar Siddiqui, EPRI Senior Technical Executive for Energy Utilization).

Strategy, Vision, and Structure of the Demand Response Roadmap

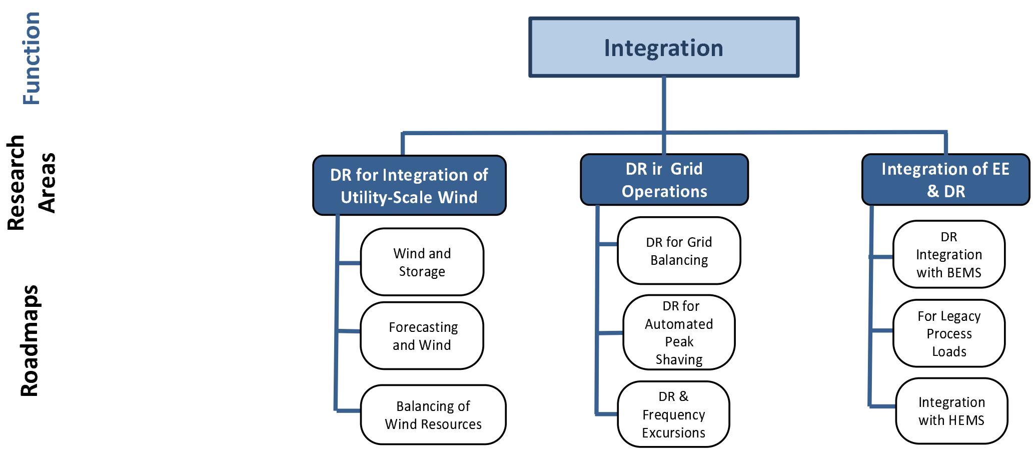


See following pages for specific technology roadmaps within each Research Area





Back to Table of Contents



Research Area Definitions

Planning

Technologies that facilitate, support, streamline, and otherwise enable and enhance transmission and generation planning

DR in Transmission & Generation Planning: Technologies used in planning processes to address existing and forecast transmission and generation needs. These technologies assist grid operators in load management and enable improved system reliability and provide imbalance reserves. These technologies while providing improved system flexibility may also enable participation in energy imbalance markets.

DR in Generation Capacity Planning: Technologies used in the generation capacity planning process to address BPA capacity needs. These technologies address hydro-generation imbalance and may provide BPA grid operators with other ancillary services.

Forecasting: Technologies involved with developing forecasts for day-ahead, hourly and sub-hourly system loads as well as balancing requirements for capacity. Examples include technologies that assist in pre-chilling and pre-heating for thermal storage. This includes technologies that assist in predictive control of DR assets as well as providing improved responsiveness to month-ahead, day-ahead, hour-ahead notification periods.

Research Area Definitions

Enabling Technologies

Technologies that enable demand response communication, controls, scheduling, confirmation, billing, and related activities

Automation and Control: Technologies with the ability to dynamically respond to signals from the grid or grid operators to control loads (INCs or DECs). This includes DR enabled devices capable of responding to sub-hourly notification and devices that provide for automatic economic dispatch. These technologies increase customer engagement and provide reliable load reductions.

Communications for DR: **T**echnologies and software protocols (BPA requires OPEN ADR2.0b) used to trigger, respond to and measure DR events. These technologies enable load augmentation in response to peak demands including technologies that are smart meter enabled. Utilizing two-way communications these technologies enable assets to provide additional capacity. These devices provide for cyber-secure economic dispatch and can facilitate participation in energy imbalance markets.

DR Capability of End Use Devices: Technologies that respond to dynamic signals from the grid or grid operators to control loads (INCs or DECs). Examples of these technologies include DR enabled automatic lighting controls, automated thermostats as well as devices for both electrical and thermal energy storage.

Measurement and Verification: Technologies and protocols (using the OPEN ADR 2.0b framework) to measure and verify load increases or decreases (INC/DEC) dispatched during a DR event, in comparison with an established energy use baseline at a site or aggregation of sites. Examples include technologies that provide measurement and verification of DR events as well as in event participation rates. This also includes devices to assist in accurate DR event settlements.

Research Area Definitions

Integration

Technologies that enable the integration of other components, systems, software, generation assets to facilitate demand response

DR in Grid Operations: Technologies that can enable demand response in response to load forecasts or dynamic grid energy or capacity requirements. These technologies allow system operators to respond to generation imbalances and result in increased system flexibility. These technologies which may typically involve a DR management system are also useful for grid regulation.

DR for Integration of Utility-Scale Wind: Technologies to address hydro-generation imbalances associated with oversupply of wind energy—such as generation oversupply and intermittent generation—and provide grid regulation services that assist in wind integration.

Integration of DR and EE: Technologies used at a site or group of sites to maximize energy efficiency and enable demand response. Examples include integrated home and business energy management systems that enable DR and provide a real-time determination of available capacity, as well as automatic lighting controls, automated thermostats, and plug load controls.

Back to Table of Contents

Determining 3–5 Priority Research Areas

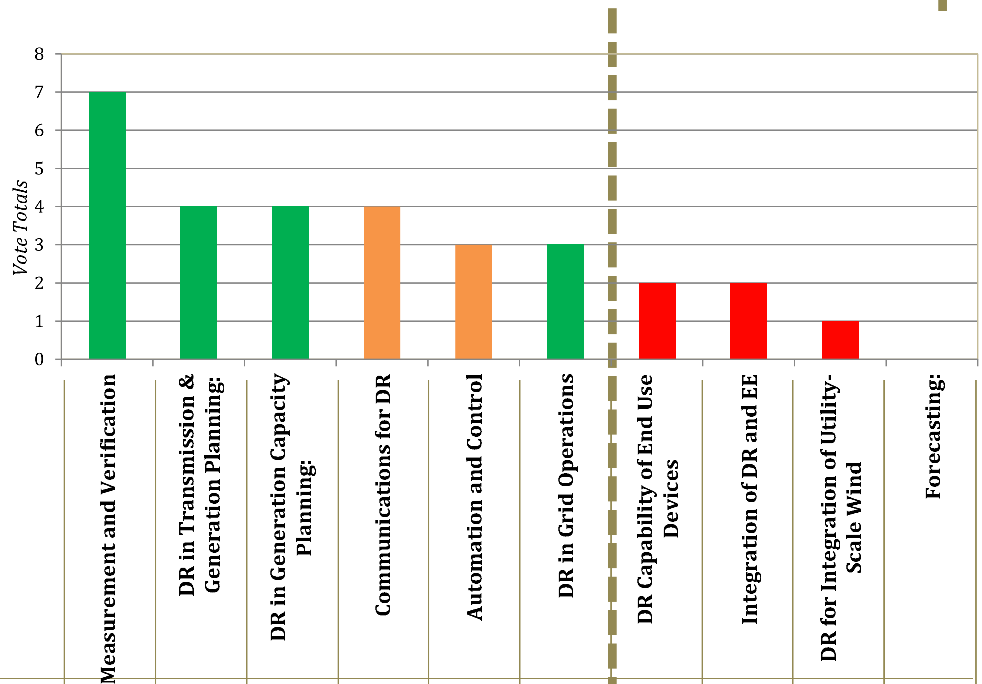
Pre-work Survey Results

Research Area	*Total*	King	Cooper	Gendron	Ehli	Génecé
DR in Grid Operations	3			1	1	1
DR Capability of End Use Devices	2	1 (5)				1
Integration of DR and EE	2			1		1
DR in Transmission & Generation Planning	4	1 (1)	1	1	1	
Forecasting	0					
DR in Generation Capacity Planning	4	1 (2)	1		1	1
Measurement and Verification	7		3	2	1	1
Automation and Control	3	1 (6)		1	1	
Communications for DR	4	1 (3)	1		1	1
DR for Integration of Utility-Scale Wind	1	1 (4)				

Pre-work Survey Results in Comparison to DR Team Priorities

DR Executive Sponsor Team

Pre-work Survey Results



	Measurement and Verification	DR in Transmission & Generation Planning:	DR in Generation Capacity Planning:	Communications for DR	Automation and Control	DR in Grid Operations	DR Capability of End Use Devices	Integration of DR and EE	DR for Integration of Utility-Scale Wind	Forecasting:
DR Team Priorities		1.5	1.5			1.5		1.5		

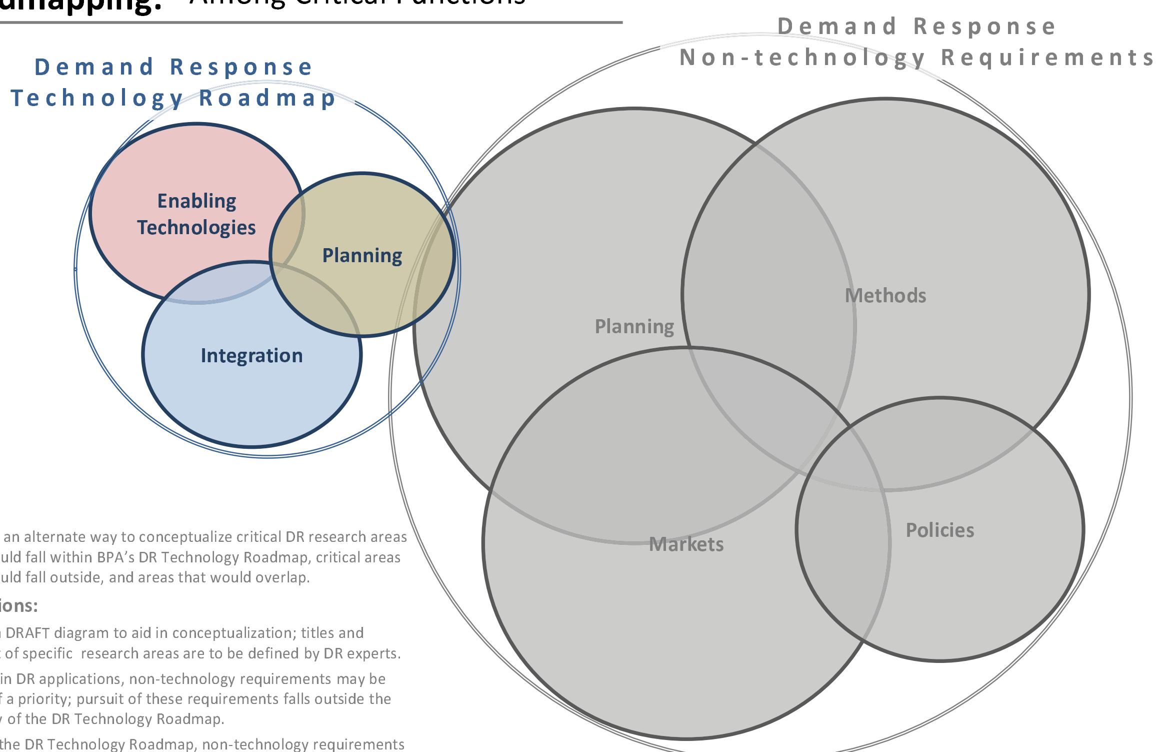
Next Steps

- Portland State University team to **create materials for Workshop 1**.
- **Workshop 1** June 13 at the Oregon State Building.
- **Workshop 2 participants** to be identified and invited based on the prioritized Research Areas.
- **DR Technology Roadmap deliverable to TI Office Nov. 10** in preparation for the FY 2016 Funding Opportunity Announcement (to be released early March 2015).

Back to Table of Contents

Backup Slides

Demand Response Roadmapping: Representing the Distinctions Between and Interrelationships Among Critical Functions



Purpose:

Provide an alternate way to conceptualize critical DR research areas that would fall within BPA's DR Technology Roadmap, critical areas that would fall outside, and areas that would overlap.

Assumptions:

- This is a DRAFT diagram to aid in conceptualization; titles and content of specific research areas are to be defined by DR experts.
- In certain DR applications, non-technology requirements may be more of a priority; pursuit of these requirements falls outside the purview of the DR Technology Roadmap.
- Within the DR Technology Roadmap, non-technology requirements may very well be critical Drivers or present important Capability Gaps that can best be overcome by developing technologies (products or services).

DRAFT May 14, 2014

Appendix 4: Workshop 1 (June 13, 2014)

Demand Response Technology Roadmap

Workshop 1

Oregon State Bldg.
800 NE Oregon St.
Portland, OR
June 13, 2014

Objectives

1) Develop consensus on teams and approach
2) Identify Drivers and Capability Gaps
3) Team presentations: Summary insights and conclusions

Agenda

8:15 a.m.	**Welcome, logistics, & introductions** **Overview of workshop objectives and roadmapping process**	Terry Oliver, BPA Tugrul Daim, PSU Thor Hinckley, BPA James Hillegas-Elting, BPA
Objective 1	**Develop consensus on teams and approach**	
9:30 a.m.	**Review draft roadmap structure** **Determine teams & establish approach**	Thor Hinckley, BPA
10:00 a.m.	***BREAK***	
Objective 2	**Identify Drivers and Capability Gaps**	
10:15 a.m.	**Identify key Drivers** **Focus Question:** 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. **Identify Capability Gaps linked to Drivers** **Focus Question:** What are the barriers or shortcomings that stand in the way of meeting Drivers?	Workshop Participants
11:30 a.m.	***WORKING LUNCH***	
12:00 p.m.	**Continue working on Objective 2**	Workshop Participants
Objective 3	**Team presentations: Summary insights and conclusions**	
2:45 p.m.	***BREAK***	
3:00 a.m.	**Team presentations & group discussion (cross fertilization)**	Workshop Participants
4:30 p.m.	**Next steps** **Workshop 2 participant suggestions** **Conclusion**	Thor Hinckley, BPA
5:00 p.m.	**Adjourn**	

Back to Table of Contents

Demand Response Technology Roadmap

Workshop 1:

Drivers & Capability Gaps

Portland, OR
June 13, 2014

Final Version June 12, 2014

Welcome, Logistics, & Introductions

This symbol—Handout—refers to pages found in the materials handed-out to you

Back to Table of Contents

Objectives

1) Develop consensus on teams and approach

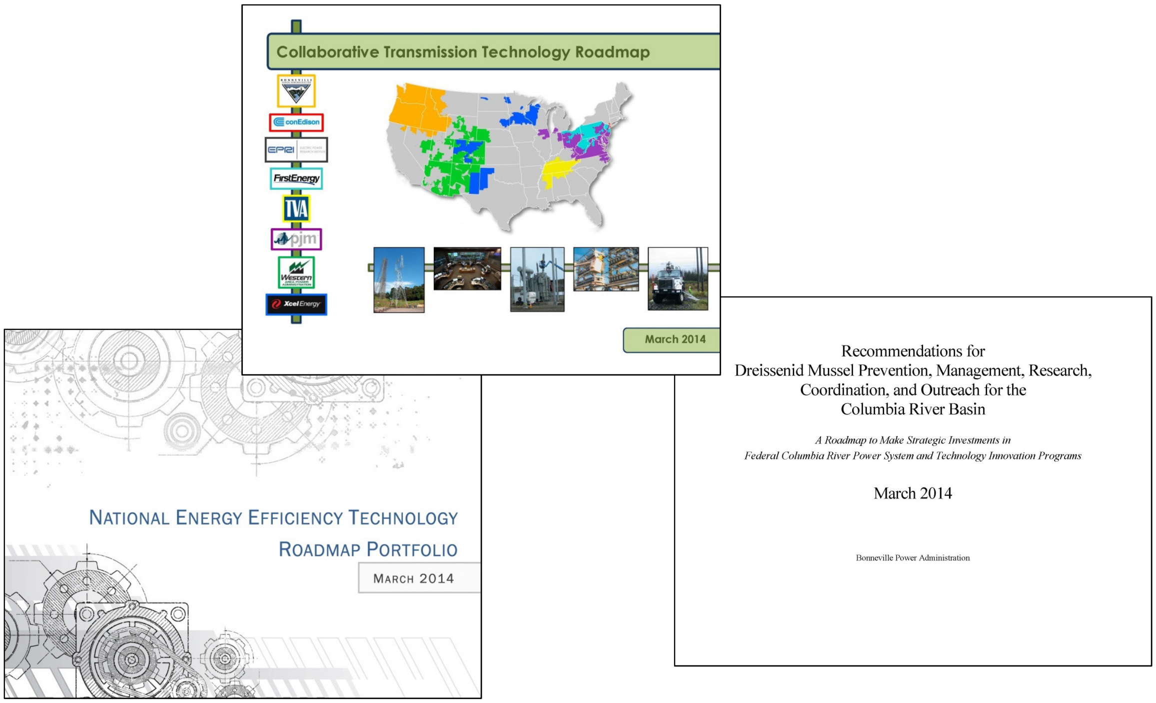
2) Identify Drivers and Capability Gaps

3) Team presentations: Summary insights and conclusions

Agenda

8:15 a.m.	Welcome, logistics, & introductions Overview of workshop objectives and roadmapping process	Terry Oliver, BPA Tugrul Daim, PSU James Hillegas-Elting, BPA James Hillegas-Elting, BPA
Objective 1	**Develop consensus on teams and approach**	
9:30 a.m.	Review draft roadmap structure Determine teams & establish approach	James Hillegas-Elting, BPA
10:00 a.m.	*BREAK*	
Objective 2	**Identify Drivers and Capability Gaps**	
10:15 a.m.	Identify key Drivers **Focus Question:** 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. Identify Capability Gaps linked to Drivers **Focus Question:** What are the barriers or shortcomings that stand in the way of meeting Drivers?	Workshop Participants
11:30 a.m.	*WORKING LUNCH*	
12:00 p.m.	Continue working on Objective 2	Workshop Participants
Objective 3	**Team presentations: Summary insights and conclusions**	
2:45 p.m.	*BREAK*	
3:00 a.m.	Team presentations & group discussion (cross fertilization)	Workshop Participants
4:30 p.m.	Next steps ~ Workshop 2 participant suggestions ~ Conclusion	James Hillegas-Elting, BPA
5:00 p.m.	Adjourn	

Technology Roadmapping at BPA



Technology Roadmapping

What?

Technology roadmapping is a tool that enables organizations to manage time and resource investments more effectively in response to increasing complexity and the accelerated pace of change. The defining elements of the roadmapping process are:

1) solicit stakeholder expertise linking technology programs with key organizational opportunities and challenges;
2) distill this expertise within an easy-to-navigate deliverable, such as a diagram, document or website; and
3) use the resultant deliverable to help guide strategic planning.

Back to Table of Contents

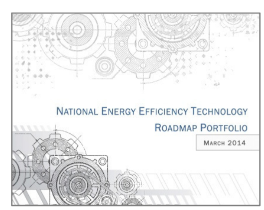
Technology Roadmapping

Why?

- Aligns organizational priorities with R&D planning and investment.
  - BPA Technology Innovation Office's annual solicitation.
- Fosters increased communication and collaboration within and beyond an organization.
- Communicates organizational technology needs to the R&D community.

Technology Roadmapping

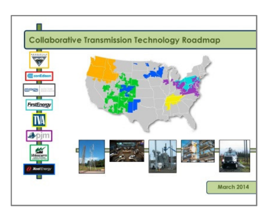
Applying Lessons Learned from the Energy Efficiency Roadmapping Experience



- BPA has facilitated EE technology roadmapping in the Pacific Northwest since 2006.
- BPA collaborated with EPRI and others in 2012 to develop the *National Energy Efficiency Technology Roadmap Portfolio*.
- In 2013 the U.N. cited this approach as a best practice in the way it clearly connects key organizational drivers with technology needs.

United Nations
Framework Convention on
Climate Change

- Also in 2013, BPA and EPRI co-led a project with six national transmission owners and operators to develop the Collaborative Transmission Technology Roadmap.



Research Area : **Technology Area Title** *Demand Response Technology Roadmap*

Roadmap: **Roadmap Title**

Drivers

Drivers: Critical factors that influence organizational decisions, operations, and strategic plans, i.e., existing or pending regulations and standards, market conditions, consumer behavior, organizational goals and culture, etc.

Increase processing efficiency

What are the reasons to change?

Capability Gaps

Capability Gaps: Barriers or shortcomings that stand in the way of meeting Drivers.

A potato peeling machine that is more efficient than existing technologies

What are the barriers to change?

Technology Characteristics

Technology Characteristics: Specific technical attributes of a product, model, system, etc., that are 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.

Thinner peeler cutting blades

What are the technological solutions needed to overcome barriers?

R&D Programs

R&D Programs: Descriptions of programs to generate new ideas for products and services, develop models and prototypes, evaluate these in laboratory settings, demonstrate them in the field, and conduct engineering and production analyses to deliver the needed Technology Characteristics. The generic abbreviation "R&D" is to be understood as including, when appropriate, design, deployment, and demonstration in addition to research and development.

Produce thinner cutting blades using the most appropriate type of metal

ACME, Inc.

What research needs to be pursued to develop technological solutions?

Handout

...lity Gap | Commercially Available Technology | Existing R&D Program or Project

Commercially Unavailable Technology | R&D Program Requirement

Timeline

March–November 2014

March–April	May 15	June 13	Sep. 18-19	Nov. 10
Planning	Principals' Meeting, Portland, OR	Workshop 1, Portland, OR	Workshop 2, Portland, OR	**Publish Demand Response Technology Roadmap**

Develop project scope and timeline.

Sponsor team approve project plan.

Discuss engagement opportunities with EPRI.

BPA DR Executive Sponsor Team to define their priority research areas in reference to agency strategies and begin to identify critical Drivers within these research areas.

Strategic experts to articulate key technology Drivers and the Capability Gaps that exist in meeting those drivers:

- Senior leadership
- Senior-level operational managers
- Other strategic and "big-picture" experts

Tactical subject matter experts to articulate Technology characteristics required to bridge Capability Gaps and R&D Program descriptions needed to develop these characteristics:

- Engineers
- Operators
- Researchers
- Academics

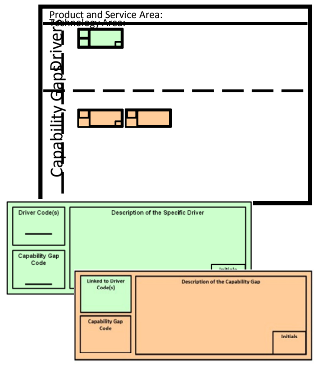
Handout

Back to Table of Contents

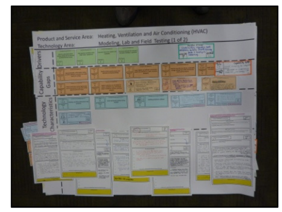
Workshop Process

Convening Workshops

Recording Content



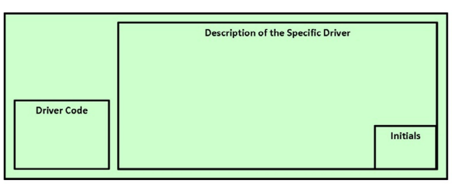
Processing Content



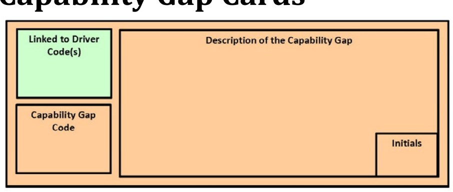
Post-workshop processing: PSU, EPRI

Workshop Process

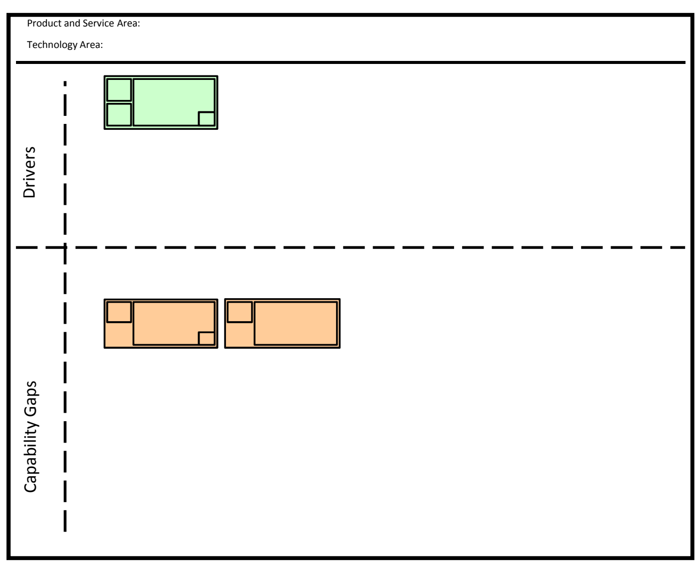
Driver Cards



Capability Gap Cards



Posters



BPA DR Definition & Objectives

Demand Response: "Changes in electric use by demand side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce changes in consumption and/or when system reliability is jeopardized."

To provide value for the agency, customers, and the region, the key objectives of BPA's DR initiatives include:

1) **Increasing system flexibility** by creating reliable DR products aligned with operational needs;
2) **Creating positive economic benefit** for BPA and utility customers by providing a portfolio of cost-effective DR products;
3) **Ensuring stakeholder satisfaction** through outreach, collaboration, and education;
4) **Strengthening regional DR knowledge**, interest, and capability; and
5) **Establishing BPA as a regional and national DR thought leader**.

BPA DR Guiding Principles

BPA's DR initiatives build a portfolio of reliable DR products that can satisfy agency operational needs more cost-effectively than alternatives. Since there is limited existing DR in the region, BPA will also focus on building regional DR knowledge, experience, and capacity by following these guiding principles:

A. BPA will utilize a **pay for performance model**.

B. BPA will **treat all potential DR providers equally**, assuming similar capability.

C. BPA will follow **minimum project size thresholds**:
   A. Demonstration = 5 MW per provider per product; and
   B. Operational DR contract = 25 MW per provider per product.

D. An operational DR product must meet the following **reliability criteria**:
   A. Deliver a useful DR product that can compete against alternatives;
   B. Achieve minimum committed size threshold;
   C. Effectively respond to at least 95% of BPA dispatch requests (unless a different target is established in the agreement);
   D. Establish reliable and defensible measurement and verification processes;
   E. Pass any and all performance audits; and
   F. Proven desire and ability to work with BPA DR and/or operational teams when challenges arise.

E. Wherever possible, align with existing teams and processes to **avoid duplicating or creating new DR-specific functions**.

Back to Table of Contents

"Organizational Chart"

Purpose:

This organizational structure is offered as one way to present, in summary form, the **core research areas and topics within demand response**. It is intended as a live, working document to help provide structure for the technology roadmapping process; it is subject to revision and refinement to reflect the dynamic nature of demand response and the input of stakeholders and subject matter experts.

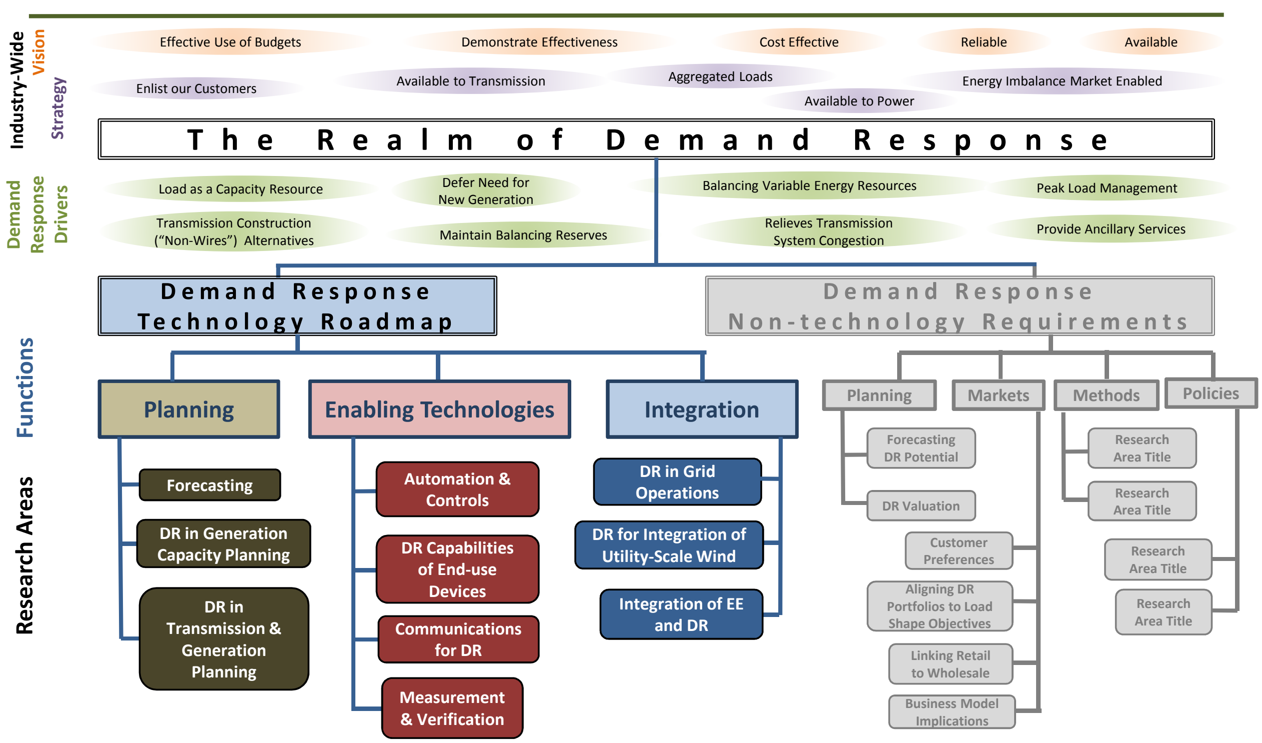
Assumptions:

Under each "Research Area" there will be one or more technology roadmaps. Thus, within the "Enabling Technologies" Function there are four Research Areas, and each of these Research Areas will be composed of one or more Roadmaps.

Authors:

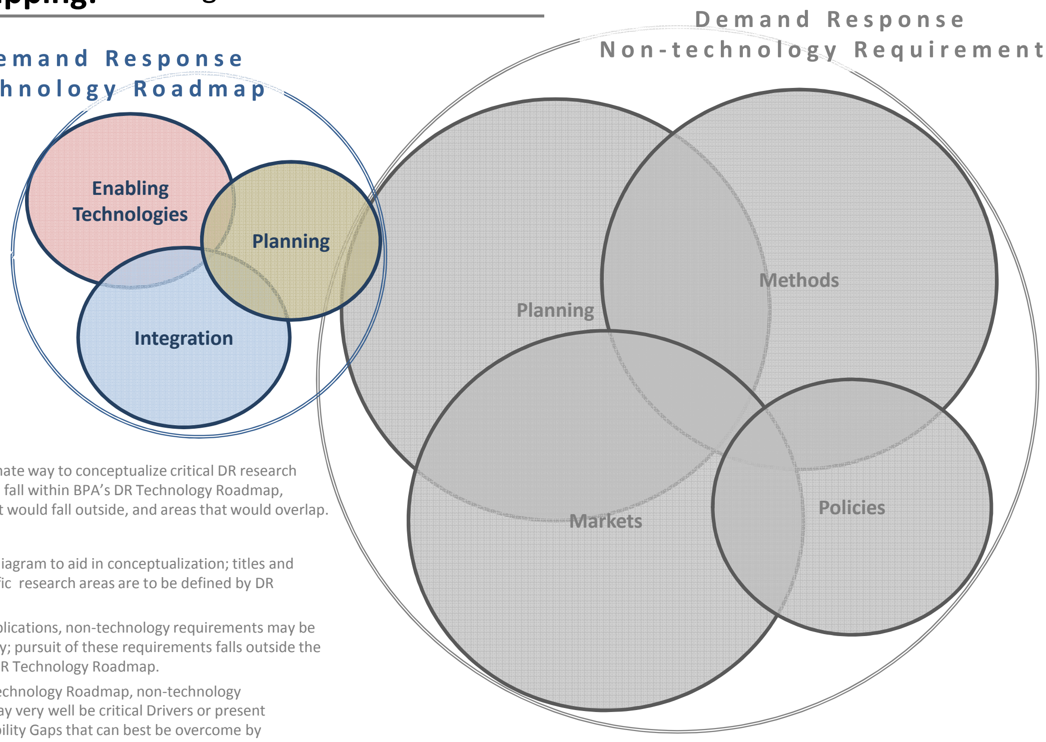
Developed based on BPA DR Team needs with input from the in-process EPRI DR Roadmapping project (led by Omar Siddiqui, EPRI Senior Technical Executive for Energy Utilization).

Strategy, Vision, and Structure of the Demand Response Roadmap



See following pages for specific technology roadmaps within each Research Area

Demand Response Roadmapping: Representing the Distinctions Between and Interrelationships Among Critical Functions



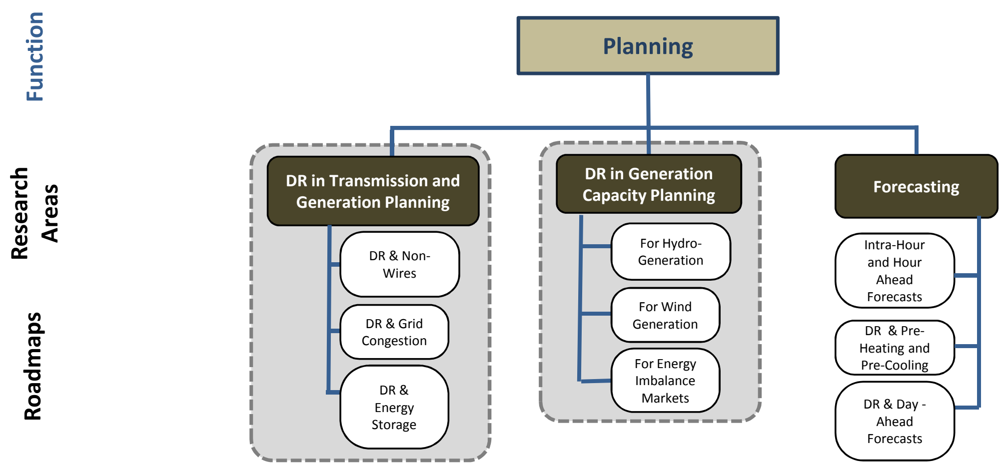
Purpose:

Provide an alternate way to conceptualize critical DR research areas that would fall within BPA's DR Technology Roadmap, critical areas that would fall outside, and areas that would overlap.

Assumptions:

- This is a DRAFT diagram to aid in conceptualization; titles and content of specific research areas are to be defined by DR experts.
- In certain DR applications, non-technology requirements may be more of a priority; pursuit of these requirements falls outside the purview of the DR Technology Roadmap.
- Within the DR Technology Roadmap, non-technology requirements may very well be critical Drivers or present important Capability Gaps that can best be overcome by developing technologies (products or services).

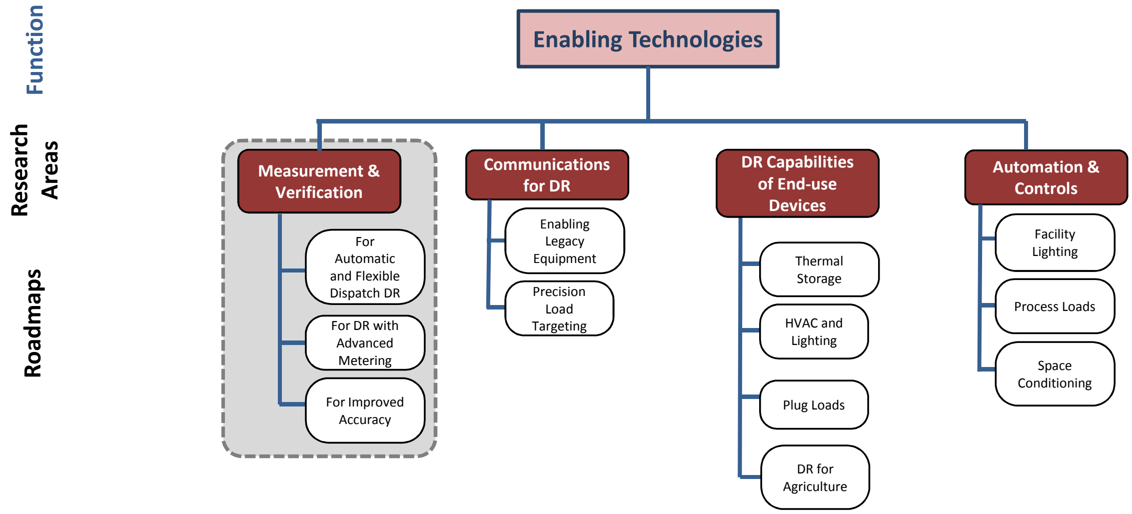
Handout



Shading indicates Research Areas selected for the 2014 project phase

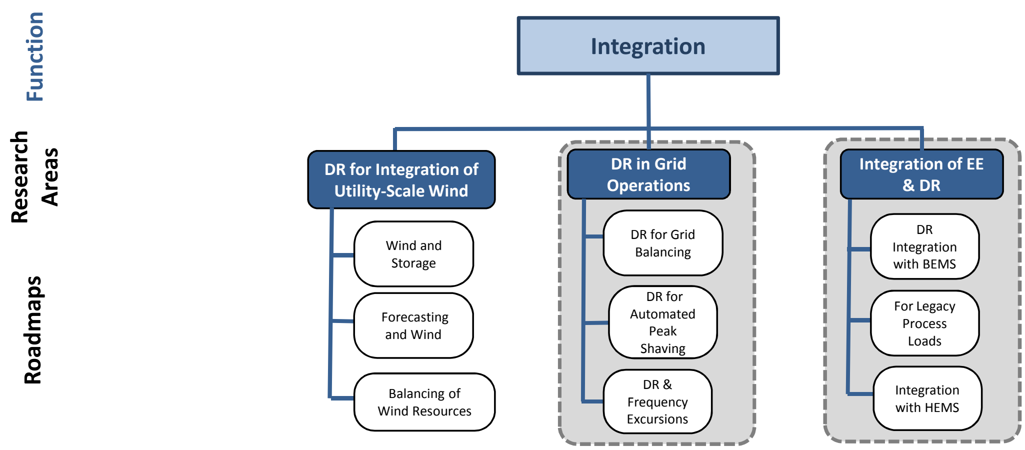
Handout

Back to Table of Contents



Shading indicates Research Areas selected for the 2014 project phase

Handout



Shaded areas denote Research Areas selected for the 2014 project phase

Handout

Research Area Definitions

Planning

Technologies that facilitate, support, streamline, and otherwise enable and enhance transmission and generation planning

DR in Transmission & Generation Planning: Technologies used in planning processes to address existing and forecast transmission and generation needs. These technologies assist grid operators in load management and enable improved system reliability and provide imbalance reserves. These technologies while providing improved system flexibility may also enable participation in energy imbalance markets.

Forecasting: Technologies involved with developing forecasts for day-ahead, hourly and sub-hourly system loads as well as balancing requirements for capacity. Examples include technologies that assist in pre-chilling and pre-heating for thermal storage. This includes technologies that assist in predictive control of DR assets as well as providing improved responsiveness to month-ahead, day-ahead, hour-ahead notification periods.

DR in Generation Capacity Planning: Technologies used in the generation capacity planning process to address BPA capacity needs. These technologies address hydro-generation imbalance and may provide BPA grid operators with other ancillary services.

Shading indicates Research Areas selected for the 2014 project phase

Research Area Definitions

Enabling Technologies

Technologies that enable demand response communication, controls, scheduling, confirmation, billing, and related activities

Automation and Control: Technologies with the ability to dynamically respond to signals from the grid or grid operators to control loads (INCs or DECs). This includes DR enabled devices capable of responding to sub-hourly notification and devices that provide for automatic economic dispatch. These technologies increase customer engagement and provide reliable load reductions.

Communications for DR: **T**echnologies and software protocols (BPA requires OPEN ADR2.0b) used to trigger, respond to and measure DR events. These technologies enable load augmentation in response to peak demands including technologies that are smart meter enabled. Utilizing two-way communications these technologies enable assets to provide additional capacity. These devices provide for cyber-secure economic dispatch and can facilitate participation in energy imbalance markets.

DR Capability of End Use Devices: Technologies that respond to dynamic signals from the grid or grid operators to control loads (INCs or DECs). Examples of these technologies include DR enabled automatic lighting controls, automated thermostats as well as devices for both electrical and thermal energy storage.

Measurement and Verification: Technologies and protocols (using the OPEN ADR 2.0b framework) to measure and verify load increases or decreases (INC/DEC) dispatched during a DR event, in comparison with an established energy use baseline at a site or aggregation of sites. Examples include technologies that provide measurement and verification of DR events as well as in event participation rates. This also includes devices to assist in accurate DR event settlements.

Shading indicates Research Areas selected for the 2014 project phase

Back to Table of Contents

Research Area Definitions

Integration

Technologies that enable the integration of other components, systems, software, generation assets to facilitate demand response

DR in Grid Operations: Technologies that can enable demand response in response to load forecasts or dynamic grid energy or capacity requirements. These technologies allow system operators to respond to generation imbalances and result in increased system flexibility. These technologies which may typically involve a DR management system are also useful for grid regulation.

DR for Integration of Utility-Scale Wind: Technologies to address hydro-generation imbalances associated with oversupply of wind energy—such as generation oversupply and intermittent generation—and provide grid regulation services that assist in wind integration.

Integration of DR and EE: Technologies used at a site or group of sites to maximize energy efficiency and enable demand response. Examples include integrated home and business energy management systems that enable DR and provide a real-time determination of available capacity, as well as automatic lighting controls, automated thermostats, and plug load controls.

Shading indicates Research Areas selected for the 2014 project phase

Handout

Preliminary Team Assignments

DR in Grid Ops

Tom Brim
Angela Chuang
Tom Coatney
Nita Zimmerman
Pete Pengilly

M&V

Ammi Amarnath
Ken Dragoon
Will Price

DR &EE

Ryan Fedie
Richard Génecé
Jeff Harris
Jenny Roehm

DR in T&G Planning

Sarah Arison
Diane Broad
Debbie Hammack
Omar Siddiqui
Don Watkins

DR in Gen Capacity Planning

Lee Hall
Jess Kincaid
Ben Kujala
Jeff Newby

Next Steps

- Roadmap team will transcribe & process (PSU) and review (EPRI) Workshop 1 output and prepare for Workshop 2 Sep. 18-19.
- Draft document will be refined and published by November 15; email notification to all contributors to solicit critical comment.
- Internal and external feedback incorporated into draft.
- March 2014 version published on the BPA Technology Innovation website as part of the FY 2016 solicitation.

Next Steps

- If you have any invitee suggestions for Workshop 2, please let us know.

Workshop 2

Objective: Within the Research Areas selected by the DR Executive Sponsor Team, identify the Technology Characteristics and R&D Programs (defined below) that address strategic Drivers and Capability Gaps identified during Workshop 1.

Schedule: Two-day by-invitation workshop on September 18–19, 2014 in Portland, OR.

Participants from Utilities, National Laboratories, Universities, R&D Organizations, Non-Governmental Organizations, Vendors, etc.: Subject matter experts from within and beyond the Pacific Northwest to develop the "tactical" roadmap content—the Technology Characteristics and R&D Programs—that can help meet the "strategic" Drivers and Capability Gaps. These experts will include engineers, operators, researchers, academics, etc., with direct and deep knowledge and experience in envisioning, developing, and analyzing technologies, models, algorithms, systems, etc.

Thank you for participating!

Contact Info:

Thor Hinckley
503.230.5533
hinckley@bpa.gov

James V. Hillegas-Elting
503.230.5327
jvhillegas@bpa.gov

Backup Slides

Workshop 1

Objective: Within the Research Areas selected by the Bonneville Power Administration's DR Executive Sponsor Team, identify strategic Drivers and Capability Gaps (defined below).

Schedule: One-day by-invitation workshop on June 13, 2014, in Portland, OR.

Participants: Senior-level leaders and operations managers involved in developing and / or implementing corporate strategy (including public policy, regulatory compliance, business development, etc.), as well as having familiarity with the role played by technologies to achieve strategic goals in demand response, smart grid, integrated demand-side management, and related areas. These experts will provide input on the "strategic" levels of the roadmap critical in developing a resource that directly supports key business objectives.

Workshop 2

Objective: Within the Research Areas selected by the DR Executive Sponsor Team, identify the Technology Characteristics and R&D Programs (defined below) that address strategic Drivers and Capability Gaps identified during Workshop 1.

Schedule: Two-day by-invitation workshop on September 18–19, 2014 in Portland, OR.

Participants from Utilities, National Laboratories, Universities, R&D Organizations, Non-Governmental Organizations, Vendors, etc.: Subject matter experts from within and beyond the Pacific Northwest to develop the "tactical" roadmap content—the Technology Characteristics and R&D Programs—that can help meet the "strategic" Drivers and Capability Gaps. These experts will include engineers, operators, researchers, academics, etc., with direct and deep knowledge and experience in envisioning, developing, and analyzing technologies, models, algorithms, systems, etc.

Back to Table of Contents

Demand Response Technology Roadmap

Workshop 1

Oregon State Bldg.
800 NE Oregon St.
Portland, OR
June 13, 2014

Team presentations: Summary insights and conclusions

Research Area: Demand Response in Grid Operations

1) Tom Brim, Bonneville Power Administration
2) Angela Chuang, Electric Power Research Institute
3) Pete Pengilly, Idaho Power Company

Angela Chuang: The team looked at three forms of DR: 1) DR for Peak Shaving (classic use with hour and day-ahead scheduling); 2) DR for Frequency Regulation (scheduling in the order of seconds); and 3) and DR for Grid Balancing (scheduling over a number of minutes). We discussed the potential to use DR for increment (INC) and decrement (DEC) as a fast response tool as well as the need for improved forecasting with improved resolution. With regards to peak shavings as a classic use of DR, we found location, location, location to be the one of the most important parameters.

Regarding Capability Gaps, we identified an important consideration as understanding what is DR's potential to turn off/on and provide flexible, cost-effective loads.

For net load forecasting we found a need for more accurate tools with better resolution.

Pete Pengilly: We also discussed the need for an integrated system to identify and launch DR programs as needed to relieve congestion and shave peaks. We also discussed the need for a demand response management system (DRMS) which is essential for integration into the utilities' Standard Operating Procedures.

We also found day ahead forecasting of congestion important for DR.

Tom Brim: DR is an important for regulation of loads as well as frequencies. We need cost effective telemetry to intersect with the Automatic Generation Control (AGC) system. We wanted to answer the question, "what does it take to become a qualified resource?"

On our Parking Lot we referred to Western Electricity Coordinating Council (WECC) and North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) guidelines as key non-technology requirements that might fall outside of this technology-focused roadmap but are, nonetheless, very important considerations.

Diane Broad: NERC CIP requirements present big challenges such as providing real-time generation data into the control center; this, in turn, ties to the need for cost effective communications.

Lee Hall: It's also important to understand how to qualify DR resources as ones that can be counted on, and map these against regulation requirements.

Back to Table of Contents

Research Area: Integration of Demand Response and Energy Efficiency

4) Ryan Fedie, Bonneville Power Administration
5) Richard Génecé, Bonneville Power Administration
6) Jeff Harris, Northwest Energy Efficiency Alliance
7) Jess Kincaid, Oregon Department of Energy
8) Jenny Roehm, Advanced Load Control Alliance

Jenny Roehm: The team started with three roadmaps titled "DR Integration with Home Energy Management Systems (BEMS)," "DR Integration with Building Energy Management Systems (HEMS)," and "DR for Legacy Process Loads." We thought a more effective organization would be to organize these into three sectors: Residential, Commercial, and Industrial. We also developed a fourth roadmap with a focus on Integrated Demand-Side Management (IDSM).

We identified a communications gap between the end load and the utility which points to the need for a common energy load data software platform (similar to Apple's iOS platform). A common platform would improve situational awareness and information on load shape profiles for the customer, the utility, and BPA or other balancing authorities.

We also noted that for identifying integrated energy efficiency (EE) & DR solutions, industrial and large commercial customers are the low-hanging fruit.

To characterize the relationship between EE and DR in a simplified and tongue-in-cheek way, we talked about EE as the equivalent of a "one-night stand" whereas DR is a much more dynamic relationship over time. That is, a given EE measure is intended to be implemented at one time and provide persistent energy savings thereafter, whereas DR solutions require an ongoing business relationship between the utility and end user. The values for EE and DR for a commercial customer can be very different. In California, for example, some customers are saving $8,000 per year by implementing EE measures while the most they could make for DR implementation would be $800 per year—and the EE solution is a one-time engagement whereas the DR solution requires ongoing collaboration. These kinds of clear financial differences influence an end user's decisions about where and when to develop an EE or a DR solution.

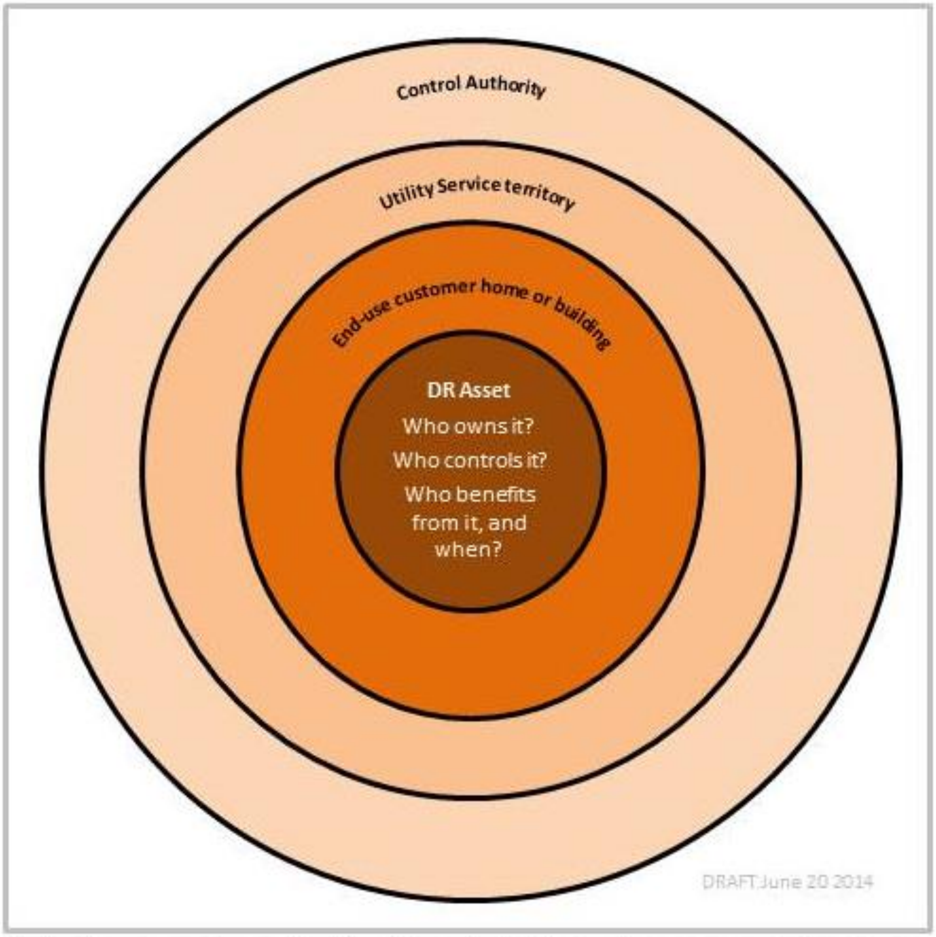
There is a gap in getting quality information as well. The need is to get accurate data— such as load shapes—at the right level of granularity and timeliness so it can be managed. Where are the intersections and integration opportunities with data that pertains to EE and to DR solutions?

Ryan Fedie: How do we understand load shapes? What is happening at different levels? How do we manage this through analytics and identify targeted marketing opportunities?

Jenny Roehm: Some of the "parking lot" items we identified included noting that DR is an ongoing relationship, and that customer's have different incentives for getting involved—thus they have to be given reasons for control.

We also noted that the use of thermal storage for meeting DR requests needs to be further developed.

The concentric circle diagram we created illustrates another important aspect [*see following page*]. Often there are also competing incentives for DR events at the levels of the customer, utility, and control authority, so it is important to identify who has priority when the DR event is to occur, and who benefits, and how the costs and benefits are allocated.



Technology requirements for integrated demand response and energy efficiency options exist within an interrelated set of considerations. Depending upon who owns, controls, and benefits from the particular demand response asset—and when the benefit occurs—there are requirements, opportunities, and challenges to consider from the perspective of the end-use customer, the utility, and the control authority.

Lee Hall: There are questions about the role of both Dynamic Voltage Regulation (DVR) and Conservation Voltage Regulation (CVR) as either EE or DR assets, which need to be resolved. It's not just a matter of determining load shape and utilizing assets like heat pump water heaters (HPWHs) to address the need, we need a portfolio of DR products to meet the needs of the BPA system. For example, there are potentially untapped benefits in looking at the loads for pumping water for municipal water systems.

Ammi Amarnath: For equipment manufactures to enable DR in their products they want the utilities to provide a "load shape" so customers can "set it and forget it." I've heard this from the manufacturers that they can incorporate this kind of functionality in their new product models, based on clear utility guidance.

Lee Hall: Having "set it and forget it" functionality may work in some instances, but I would argue that it's also critically important to enable two-way communications with those loads. For some of the more advanced "DR 2.0" kinds of functionality, communication to and from the end-use equipment is essential.

Omar Siddiqui: Did your team discuss how variable capacity drives for all manner of equipment will impact the DR markets? As these types of systems become more popular they will effect facility load shapes much like we see with residential HPWHs.

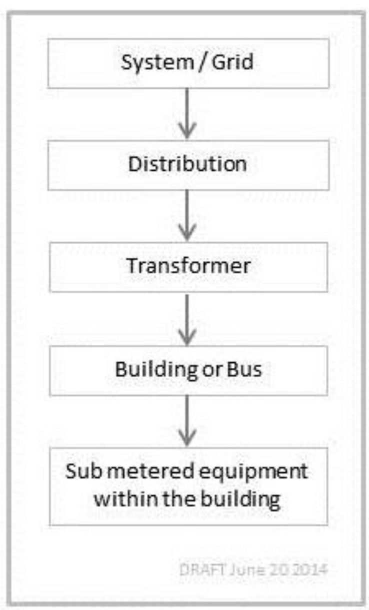
Jenny Roehm: Utilities also need advanced metering infrastructure (AMI) to implement fully the benefits of smart appliances.

Research Area: Measurement and Verification

9) Ammi Amarnath, Electric Power Research Institute
10) Ken Dragoon, Ecofys
11) Will Price, Eugene Water & Electric Board

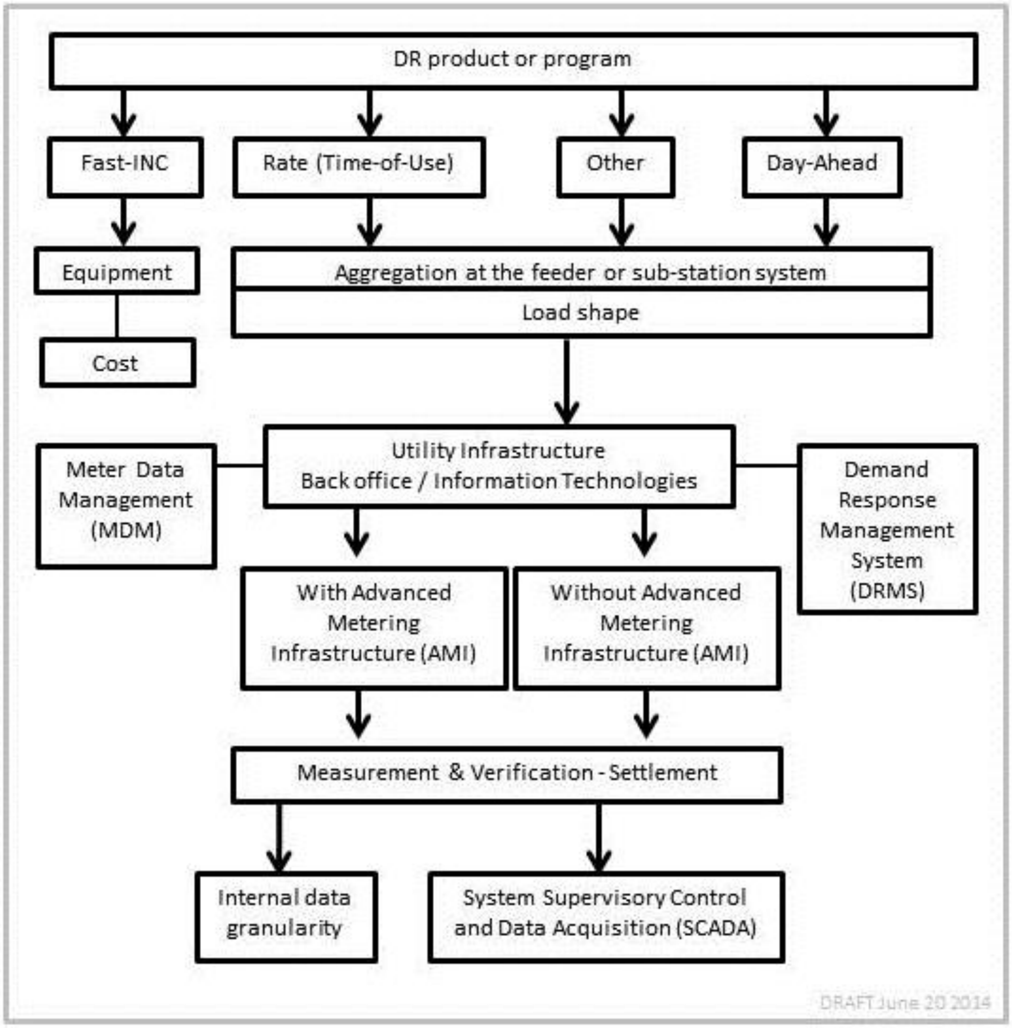
Ammi Amarnath: When we first started work on our roadmap posters we didn't change the headings, although the titles and organization we were given wouldn't be the way we would organize the topics. However, in the context of achieving the goals of the workshop we agreed that the critical first-step in the measurement and verification process is to understand the baseline because this will drive the evolution of multiple DR offerings.

Ken Dragoon: Determining the baseline, however, will be different at the various levels—it'll be different at the transmission grid level, the distribution level, and on down to the level of sub-metering at the building. We drew a diagram [*see below*] on one of our posters to illustrate this.



Determining the baseline is the critical first step in the measurement & verification process, and doing so is different at different levels.

Will Price: In thinking-through what might be a more effective organization for the roadmaps within this Research Area, I sketched on our "parking lot" a diagram that might be of help [*see following page*]. There are some aspects of this diagram that point more to the need for practices, methods, or policies rather than technologies. One of the primary dividing points in this structure will involve the technology of AMI because there is an important distinction between the kinds of DR M&V solutions that could be offered with and without AMI being available.



Measurement & Verification (M&V) organizational structure and process flow diagram identifying primary categories where technologies may be needed. Opportunities to enhance M&V technologies and protocols will differ based not only on the kind of DR product or program, but also on the utility data management and information technology infrastructure and whether or not AMI is installed.

Richard Génecé: A regional and national load-shape library can be used with advanced technologies to provide cost effective solutions. My experience has been that customers think in terms of off/on rather than the full range of DR potential they could realize.

Lee Hall: This highlights again the need for two-way communications, because otherwise how will the utility know there has been a response when a DR event has been called?

Research Area: Demand Response in Transmission and Generation Planning

12) Sarah Arison, Bonneville Power Administration
13) Diane Broad, Oregon Department of Energy
14) Debbie Hammack, Bonneville Power Administration
15) Omar Siddiqui, Electric Power Research Institute
16) Don Watkins, Bonneville Power Administration
17) Nita Zimmerman, Bonneville Power Administration

Omar Siddiqui: A central theme of our group was that planners don't like uncertainty, and DR has plenty of perceived uncertainties. This makes planners skittish about DR.

Within this context we looked at DR options as solutions for both transmission construction alternatives ("non-wires") and location-specific transmission grid congestion—that is, we looked at DR in both space and time. There is a need for visibility into the amount of location-specific DR as a way to defer new generation to deal with load growth or gas peaking plants. There is a lot of uncertainly in load growth projections. How can DR positively affect system use? Again, we found that there are perceptual barriers among transmission planners regarding DR; generally they are skeptical and need to see it demonstrated before they consider DR a viable solution. We concluded that to optimize DR it pays to involve transmission planners early in the process to enlist their support.

We had a lot of discussion around thermal storage solutions such as water heaters. Clearly there is a lack of DR-ready water heater technologies that could be sold into the market. We also discussed the early stages of a trend toward HPWHs demonstrating that DR and EE are not always aligned or mutually supportive.

In our discussion of battery storage options our conclusion was that the technology is available but decisions about this generally come down to costs.

We also found that there is a shortage of subject matter experts involved in the non-wires planning world who have both transmission planning and DR experience. This isn't a technology-based Capability Gap necessarily, but a critical one nonetheless.

Ammi Amarnath: I believe we should look at the dis-aggregation of multiple DR loads to identify the very best loads to curtail. There are also vehicle-to-grid storage opportunities that we should be thinking about. NV Energy in Nevada, for example, is currently working on a number of large DR assets that it can use to shave peaks.[1]

Jenny Roehm: In my extensive experience with utilities throughout North America, I have consistently found that once planners see the load drop after a DR event is called, they "get it" and want even more.

Ammi Amarnath: Also, Florida Power and Light has approximately 2,000 MW of DR available, and we've produced a study on this topic that is publically available.[2]

Omar Siddiqui: We need better load growth forecasting tools.

---

[1] See, for example, Mark Triplett, "Assessing the Business Case for Demand Response," *Electricity Policy*, Nov. 2013, p. 5, available at http://www.alstom.com/Global/Grid/Resources/Documents/Assessing-the-Business-Case-for-Demand-Response.pdf, accessed June 24, 2014.

[2] *Citation pending*.

Ben Kujala: As we'll talk about in more detail in a few minutes when our work team presents, we changed our Research Area title to "Demand Response 2.0" because we were conflicted on the need to incorporate DR into both transmission and generation planning. So, we decided to focus on DR planning to meet the need for balancing reserves and to increase system flexibility, as well as dispatching DR in ways that meets both transmission and generation planning needs. We also had a lot of discussion about the value of DR as a way to downsize a utility's distribution system.

Lee Hall: I'll note that Navigant's Pacific Northwest Smart Grid Demonstration Project (PNWSGDP) Regional Business case found a net positive effect for CVR and even for the Primus battery storage project on Bainbridge Island.[3]

Jenny Roehm: We need a way to assess the value of DR measures to both transmission and distribution systems.

Ryan Fedie: There is also a lack of detailed end-use data on how customers use energy.

Research Area: Demand Response 2.0 (*Note: Team changed the Research Area title from "Demand Response in Generator Capacity Planning"*)

18) Lee Hall, Bonneville Power Administration
19) Ben Kujala, Northwest Power and Conservation Council
20) Jeff Newby, Bonneville Power Administration

Ben Kujala: As I mentioned earlier, we decided to change the name of this Research Area because of the significant overlaps we perceived between the definition of this Research Area, "Demand Response in Transmission and Generation Planning," and to some degree "Demand Response in Grid Operations." We focused on planning for the need for balancing and system flexibility as well as the need for communications to facilitate better integration. We wanted to get at how DR can be optimized to maximize BPA's generation resources and provide added flexibility for integrating intermittent renewable resources such as wind. We also discussed using DR to mitigate existing transmission congestion.

We realized the DR used for integration needs to be verifiable, since DR is so dynamic operators may miss it. We need a real-time display of DR availability and a means of valuing it.

There is also a need for aggregated dispatch of DR for optimal control of hydro generation and river flows and to deal with transmission congestion. We also wanted to find ways to use DR to meet regional needs as well as, possibly, other needs beyond the Pacific Northwest.

We discussed a battery analogy where aggregated DR loads are held until needed, similar to how a battery can be used to extract more value from a hydro generator. We also discussed using DR as a CO_2-free capacity hedge for variable energy resources.

Overall we wanted to explore ways to use DR as a multi-dimensional tool to add flexibility to the BPA hydro and transmission systems. We highlighted the need for algorithms to help identify the value from DR.

---

[3] See "Smart Grid Regional Business Case for the Pacific Northwest: Interim Results & Analysis," Version 1.0, Dec. 17, 2013, produced by Navigant Consulting, Inc., for the Bonneville Power Administration, available at http://www.bpa.gov/Projects/Initiatives/SmartGrid/DocumentsSmartGrid/Navigant-BPA-PNW-Smart-Grid-Regional-Business-Case-2013-White-Paper.pdf, accessed June 24, 2014.

In our "Parking Lot" we included the need to identify ways to coordinate communications across the BPA system to maximize the value from DR assets since there are clearly multiple needs that DR can address. This highlights something that may not require technologies, per se, but definitely will require tailored policies, agreements, protocols, etc.

BPA is currently using power contracts for some of its capacity needs which may be a substitute for DR. Also, the development of an energy imbalance market (EIM) / Security Constrained Economic Dispatch (SCED) market with the California Independent System Operator (CAISO) will make DR more valuable and begin to influence BPA's Open Access Tariffs.

Sarah Arison: I'll note that a team within BPA Transmission Services is working to address the EIM issue by identifying ways to increase the visibility of available transmission capacity on the system.

Appendix 5: Workshop 2 (Sep. 18-19, 2014)

Demand Response Technology Roadmap

Workshop 2

Oregon State Bldg. Room 1B
800 NE Oregon St.
Portland, OR
September 18–19, 2014

Objectives

1) **Day 1:** Develop consensus on teams and approach
2) **Day 1:** Identify Technology Characteristics and R&D Programs
3) **Day 2:** Prioritize R&D Programs and prepare for team presentations
4) **Day 2:** Team presentations: Summary insights and conclusions

Agenda – Day 1

9:00 a.m.	**Welcome, logistics, & introductions** **Overview of workshop objectives and roadmapping process** **Demand Response in the Pacific Northwest**	Elliot Mainzer, BPA James Hillegas-Elting, BPA Dr. Tugrul Daim, PSU Kim Thompson, BPA Thor Hinckley, BPA
Objective 1	**Develop consensus on teams and approach**	
10:30 a.m.	**Review draft roadmap structure** **Determine teams & establish approach**	James Hillegas-Elting, BPA
11:00 a.m.	***BREAK***	
Objective 2	**Identify Technology Characteristics and R&D Programs**	
11:15 a.m.	**Identify Technology Characteristics linked to Capability Gaps** **Focus Question:** 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? **Identify R&D Programs linked to Technology Characteristics** **Focus Question:** 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?	Workshop Participants
12:00 p.m.	***WORKING LUNCH***	
12:45 p.m.	**Continue working on Objective 2**	Workshop Participants
2:45 p.m.	***BREAK***	
3:30 p.m.	**Preparation for Day 2**	James Hillegas-Elting, BPA
4:00 p.m.	**Adjourn**	

Demand Response Technology Roadmap

Workshop 2

Oregon State Bldg. Room 1B
800 NE Oregon St.
Portland, OR
September 18–19, 2014

Objectives

1) **Day 1:** Develop consensus on teams and approach
2) **Day 1:** Identify Technology Characteristics and R&D Programs
3) **Day 2:** Prioritize R&D Programs and prepare for team presentations
4) **Day 2:** Team presentations: Summary insights and conclusions

Agenda – Day 2

9:00 a.m.	**Welcome** **Recap of Day 1 and preparation for Day 2**	James Hillegas-Elting, BPA
Objective 3	**Prioritize R&D Programs and prepare for team presentations**	
9:15 a.m.	**Review Day 1 output** **Prioritize R&D Programs** **Focus Question:** On a three-tiered scale, what is the relative importance of each R&D Program toward realizing the linked Technology Characteristic(s)? *(Green = High, Yellow = Medium, Red = Low)* **Prepare for Team Presentations**	Dr. Tugrul Daim, PSU Workshop Participants
10:15 a.m.	***BREAK***	
Objective 4	**Team presentations: Summary insights and conclusions**	
10:30 a.m.	**Team presentations & group discussion (cross fertilization)** **Focus Question:** What are the key takeaways, summary highlights, and most important lessons-learned that the team discussed and documented?	Workshop Participants
11:00 p.m.	***WORKING LUNCH**: Continue team presentations & group discussion*	
	Continue working on Objective 3	Workshop Participants
11:45 a.m.	**Wrap-up & Next steps**	James Hillegas-Elting, BPA
12:00 p.m.	**Adjourn**	

Demand Response Technology Roadmap

Workshop 2:

Technology Characteristics and R&D Programs

Portland, OR
September 18–19, 2014

Version September 16, 2014

Welcome, Logistics, & Introductions

This symbol—Handout—refers to pages found in the materials handed-out to you

Back to Table of Contents

Objectives

1) Day 1: Develop consensus on teams and approach
2) Day 1: Identify Technology Characteristics and R&D Programs
3) Day 2: Prioritize R&D Programs and Prepare for Team Presentations
4) Day 2: Team presentations: Summary insights and conclusions

Agenda: Day1

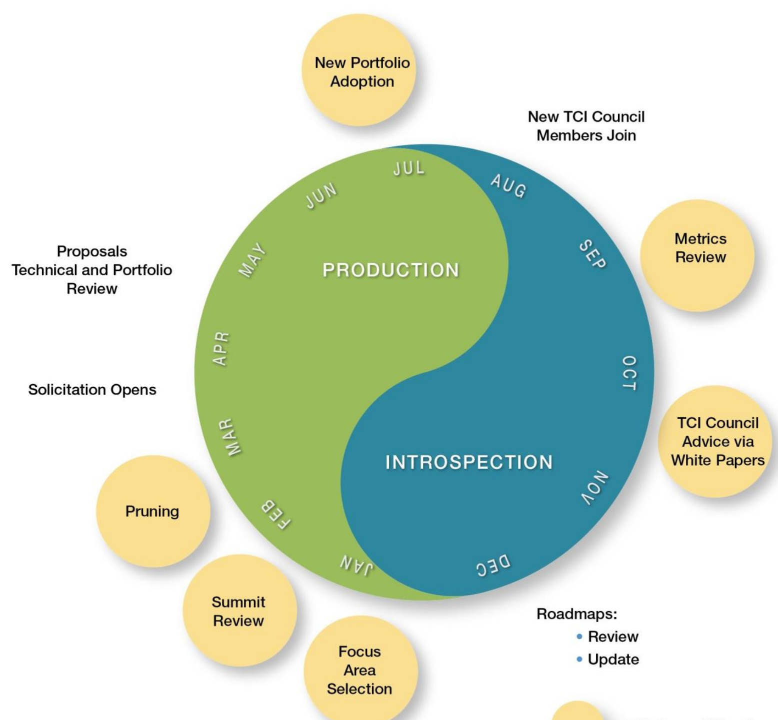
9:00 a.m.	**Welcome, logistics, & introductions** **Overview of workshop objectives and roadmapping process** **Demand Response in the Pacific Northwest**	Mark Gendron, BPA James Hillegas-Elting, BPA Dr. Tugrul Daim, PSU Kim Thompson, BPA Thor Hinckley, BPA
Objective 1	**Develop consensus on teams and approach**	
10:30 a.m.	**Review draft roadmap structure** **Determine teams & establish approach**	James Hillegas-Elting, BPA
11:00 a.m.	*BREAK*	
Objective 2	**Identify Technology Characteristics and R&D Programs**	
11:15 a.m.	**Identify Technology Characteristics linked to Capability Gaps** **Focus Question:** 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? **Identify R&D Programs linked to Technology Characteristics** **Focus Question:** 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?	Workshop Participants
12:00 p.m.	*WORKING LUNCH*	
12:45 p.m.	**Continue working on Objective 2**	Workshop Participants
2:45 p.m.	*BREAK*	
3:30 p.m.	**Preparation for Day 2**	James Hillegas-Elting, BPA
4:00 p.m.	**Adjourn**	

Agenda: Day2

9:00 a.m.	**Welcome** **Recap of Day 1 and preparation for Day 2**	James Hillegas-Elting, BPA
Objective 3	**Prioritize R&D Programs and prepare for team presentations**	
9:15 a.m.	**Review Day 1 output** **Prioritize R&D Programs** **Focus Question:** On a three-tiered scale, what is the relative importance of each R&D Program toward realizing the linked Technology Characteristic(s)? *(Green = High, Yellow = Medium, Red = Low)* **Prepare for Team Presentations**	Dr. Tugrul Daim, PSU Workshop Participants
10:15 a.m.	***BREAK***	
Objective 4	**Team presentations: Summary insights and conclusions**	
10:30 a.m.	**Team presentations & group discussion (cross fertilization)** **Focus Question:** What are the key takeaways, summary highlights, and most important lessons-learned that the team discussed and documented?	Workshop Participants
11:00 p.m.	***WORKING LUNCH**: Continue team presentations & group discussion*	
	Continue working on Objective 3	Workshop Participants
11:45 a.m.	**Wrap-up & Next steps**	James Hillegas-Elting, BPA
12:00 p.m.	**Adjourn**	

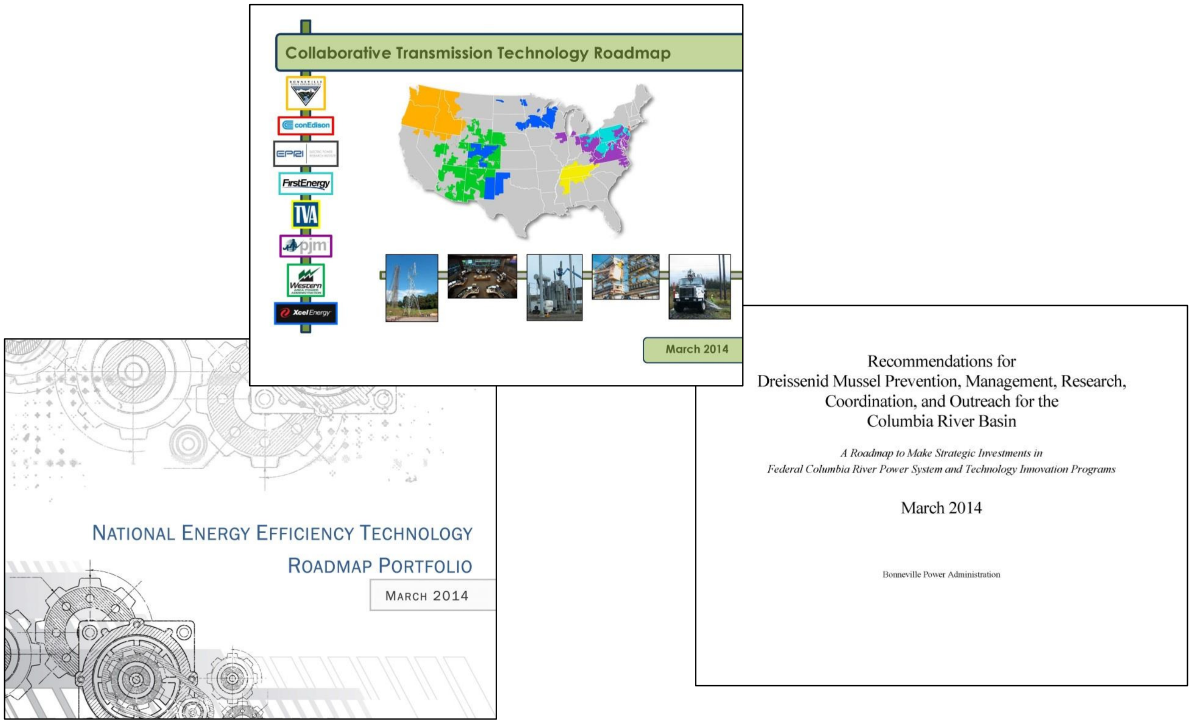
Handout

BPA Technology Innovation



Back to Table of Contents

Technology Roadmapping at BPA



Technology Roadmapping

What?

Technology roadmapping is a tool that enables organizations to manage time and resource investments more effectively in response to increasing complexity and the accelerated pace of change. The defining elements of the roadmapping process are:

1) solicit stakeholder expertise linking technology programs with key organizational opportunities and challenges;
2) distill this expertise within an easy-to-navigate deliverable, such as a diagram, document or website; and
3) use the resultant deliverable to help guide strategic planning.

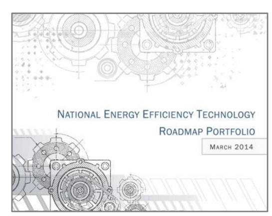
Technology Roadmapping

Why?

- Aligns organizational priorities with R&D planning and investment.
  - BPA Technology Innovation Office's annual solicitation.
- Fosters increased communication and collaboration within and beyond an organization.
- Communicates organizational technology needs to the R&D community.

Technology Roadmapping

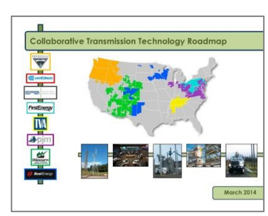
Applying Lessons Learned from the Energy Efficiency Roadmapping Experience



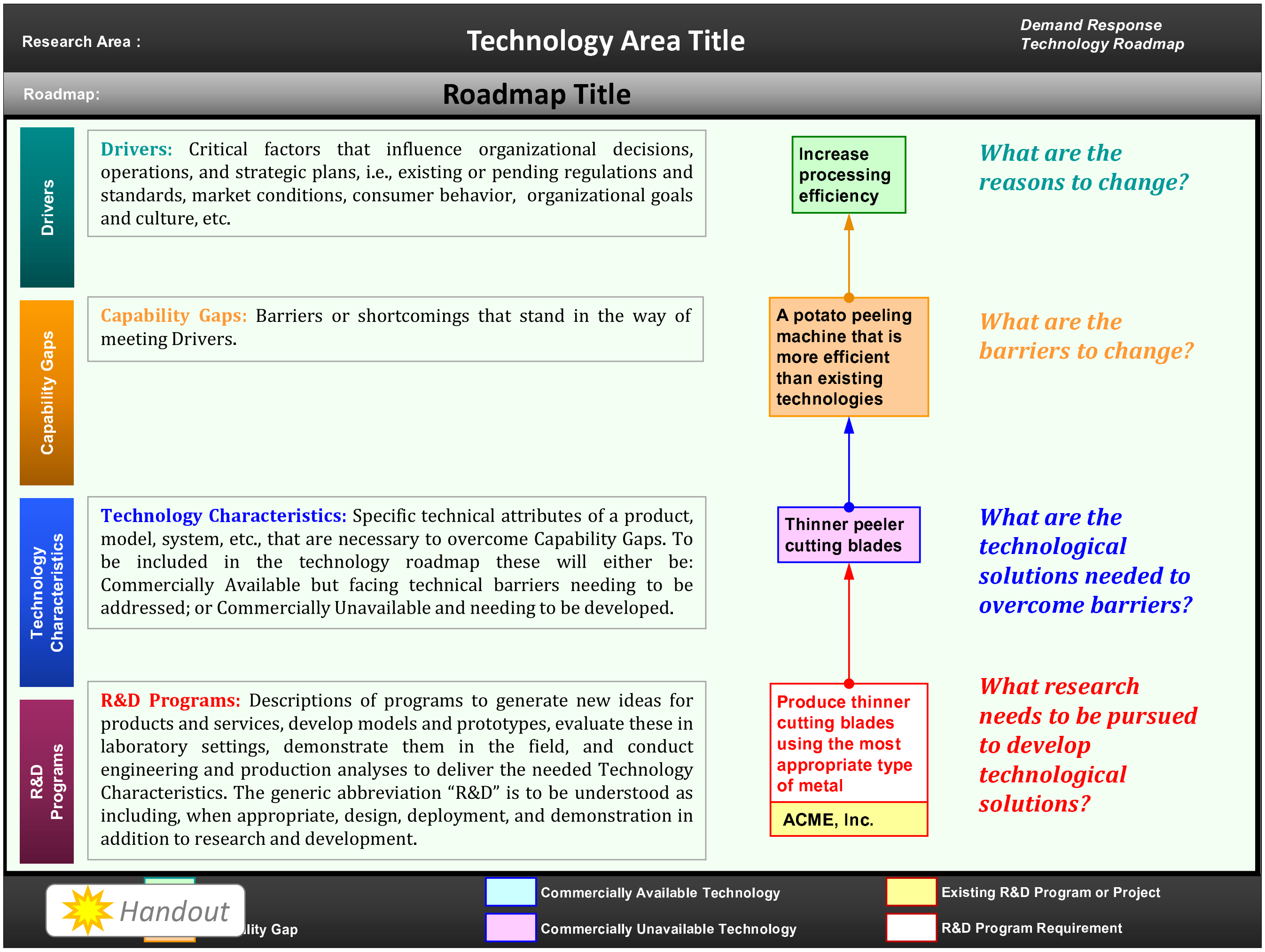
- BPA has facilitated EE technology roadmapping in the Pacific Northwest since 2006.
- BPA collaborated with EPRI and others in 2012 to develop the *National Energy Efficiency Technology Roadmap Portfolio*.
- In 2013 the U.N. cited this approach as a best practice in the way it clearly connects key organizational drivers with technology needs.

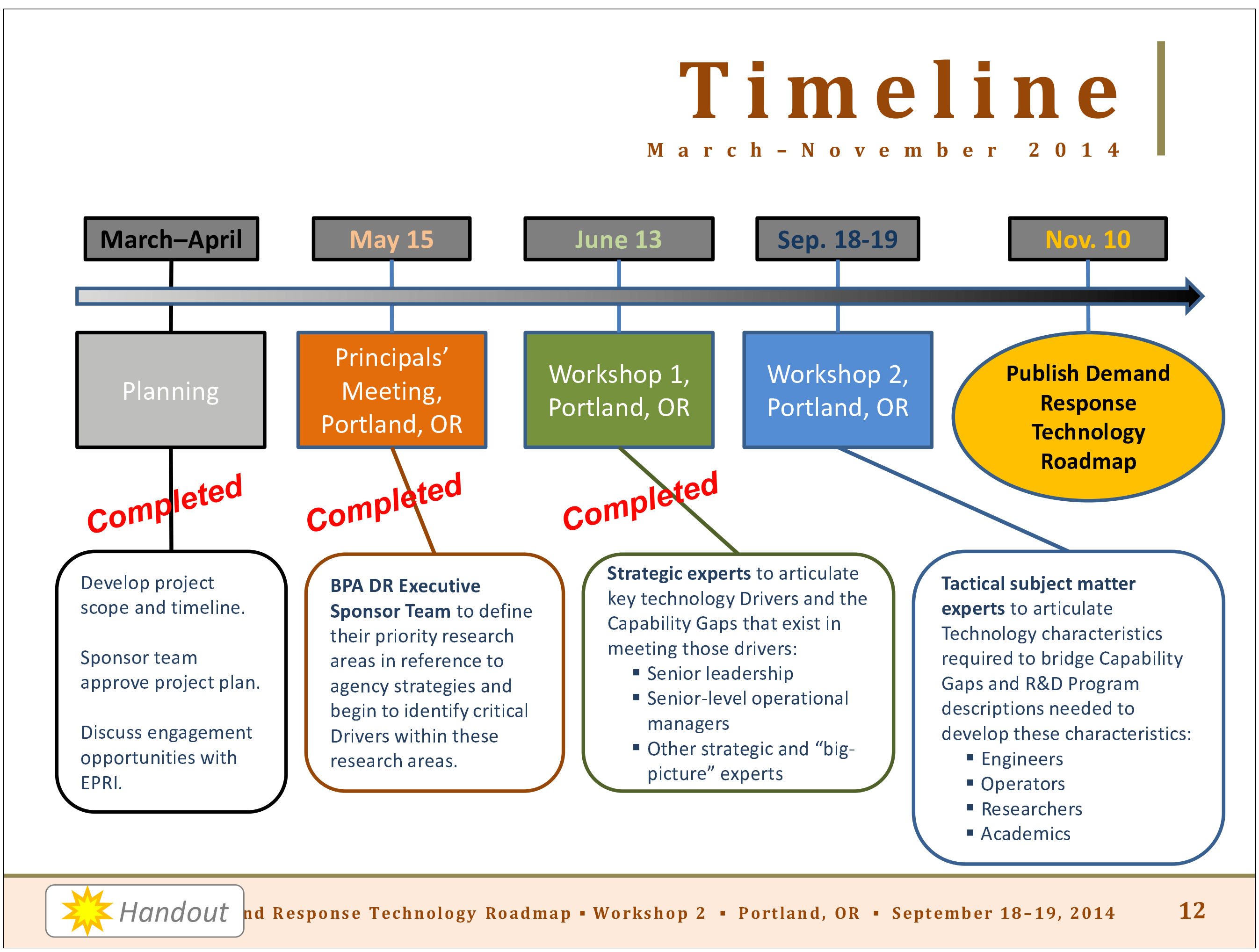
United Nations
Framework Convention on
Climate Change

- Also in 2013, BPA and EPRI co-led a project with six national transmission owners and operators to develop the Collaborative Transmission Technology Roadmap.



Back to Table of Contents


Research Area :
Technology Area Title
Demand Response Technology Roadmap
Roadmap:
Roadmap Title
Drivers
Drivers: Critical factors that influence organizational decisions, operations, and strategic plans, i.e., existing or pending regulations and standards, market conditions, consumer behavior, organizational goals and culture, etc.
Increase processing efficiency
What are the reasons to change?
Capability Gaps
Capability Gaps: Barriers or shortcomings that stand in the way of meeting Drivers.
A potato peeling machine that is more efficient than existing technologies
What are the barriers to change?
Technology Characteristics
Technology Characteristics: Specific technical attributes of a product, model, system, etc., that are 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.
Thinner peeler cutting blades
What are the technological solutions needed to overcome barriers?
R&D Programs
R&D Programs: Descriptions of programs to generate new ideas for products and services, develop models and prototypes, evaluate these in laboratory settings, demonstrate them in the field, and conduct engineering and production analyses to deliver the needed Technology Characteristics. The generic abbreviation "R&D" is to be understood as including, when appropriate, design, deployment, and demonstration in addition to research and development.
Produce thinner cutting blades using the most appropriate type of metal
ACME, Inc.
What research needs to be pursued to develop technological solutions?
Handout
lity Gap
Commercially Available Technology
Commercially Unavailable Technology
Existing R&D Program or Project
R&D Program Requirement


Timeline
March – November 2014
March–April
May 15
June 13
Sep. 18-19
Nov. 10
Planning
Principals' Meeting, Portland, OR
Workshop 1, Portland, OR
Workshop 2, Portland, OR
Publish Demand Response Technology Roadmap
Completed
Completed
Completed
Develop project scope and timeline.
Sponsor team approve project plan.
Discuss engagement opportunities with EPRI.
BPA DR Executive Sponsor Team to define their priority research areas in reference to agency strategies and begin to identify critical Drivers within these research areas.
Strategic experts to articulate key technology Drivers and the Capability Gaps that exist in meeting those drivers:
▪ Senior leadership
▪ Senior-level operational managers
▪ Other strategic and "big-picture" experts
Tactical subject matter experts to articulate Technology characteristics required to bridge Capability Gaps and R&D Program descriptions needed to develop these characteristics:
▪ Engineers
▪ Operators
▪ Researchers
▪ Academics
Handout
nd Response Technology Roadmap ▪ Workshop 2 ▪ Portland, OR ▪ September 18–19, 2014
12

BPA DR Definition & Objectives

Demand Response: "Changes in electric use by demand side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce changes in consumption and/or when system reliability is jeopardized."

To provide value for the agency, customers, and the region, the key objectives of BPA's DR initiatives include:

1) **Increasing system flexibility** by creating reliable DR products aligned with operational needs;
2) **Creating positive economic benefit** for BPA and utility customers by providing a portfolio of cost-effective DR products;
3) **Ensuring stakeholder satisfaction** through outreach, collaboration, and education;
4) **Strengthening regional DR knowledge**, interest, and capability; and
5) **Establishing BPA as a regional and national DR thought leader**.

Handout

BPA DR Guiding Principles

BPA's DR initiatives build a portfolio of reliable DR products that can satisfy agency operational needs more cost-effectively than alternatives. Since there is limited existing DR in the region, BPA will also focus on building regional DR knowledge, experience, and capacity by following these guiding principles:

A. BPA will utilize a **pay for performance model**.

B. BPA will **treat all potential DR providers equally**, assuming similar capability.

C. BPA will follow **minimum project size thresholds**:
   - A. Demonstration = 5 MW per provider per product; and
   - B. Operational DR contract = 25 MW per provider per product.

D. An operational DR product must meet the following **reliability criteria**:
   - A. Deliver a useful DR product that can compete against alternatives;
   - B. Achieve minimum committed size threshold;
   - C. Effectively respond to at least 95% of BPA dispatch requests (unless a different target is established in the agreement);
   - D. Establish reliable and defensible measurement and verification processes;
   - E. Pass any and all performance audits; and
   - F. Proven desire and ability to work with BPA DR and/or operational teams when challenges arise.

E. Wherever possible, align with existing teams and processes to **avoid duplicating or creating new DR-specific functions**.

Handout

Back to Table of Contents

"Organizational Chart"

Purpose:

This organizational structure is offered as one way to present, in summary form, the **core research areas and topics within demand response**. It is intended as a live, working document to help provide structure for the technology roadmapping process; it is subject to revision and refinement to reflect the dynamic nature of demand response and the input of stakeholders and subject matter experts.

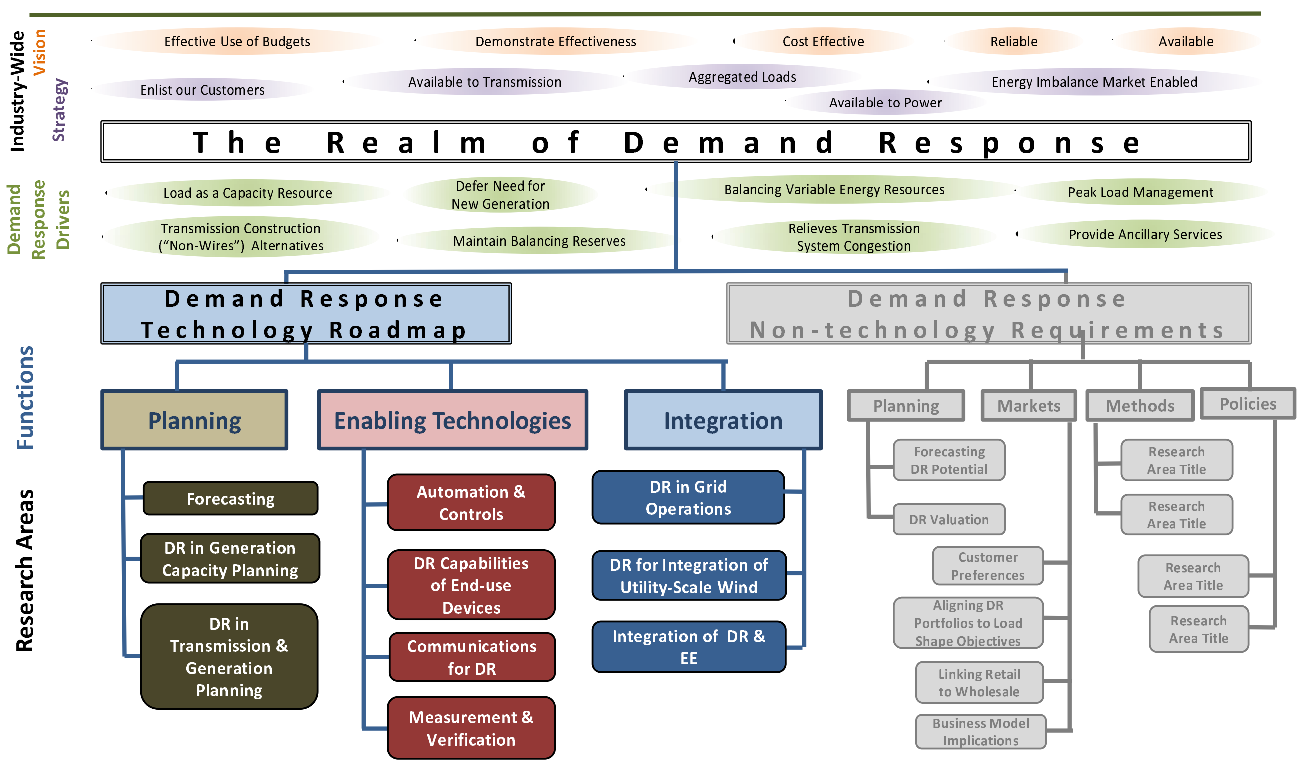
Assumptions:

Under each "Research Area" there will be one or more technology roadmaps. Thus, within the "Enabling Technologies" Function there are four Research Areas, and each of these Research Areas will be composed of one or more Roadmaps.

Authors:

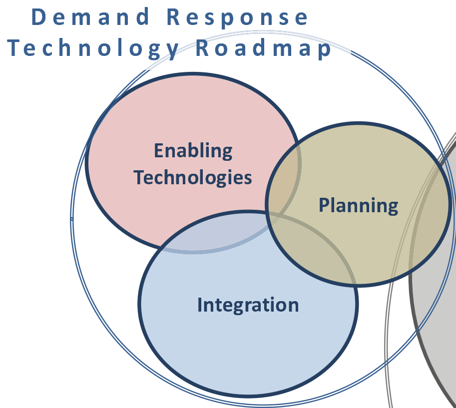
Developed based on BPA DR Team needs with input from the in-process EPRI DR Roadmapping project (led by Omar Siddiqui, EPRI Senior Technical Executive for Energy Utilization).

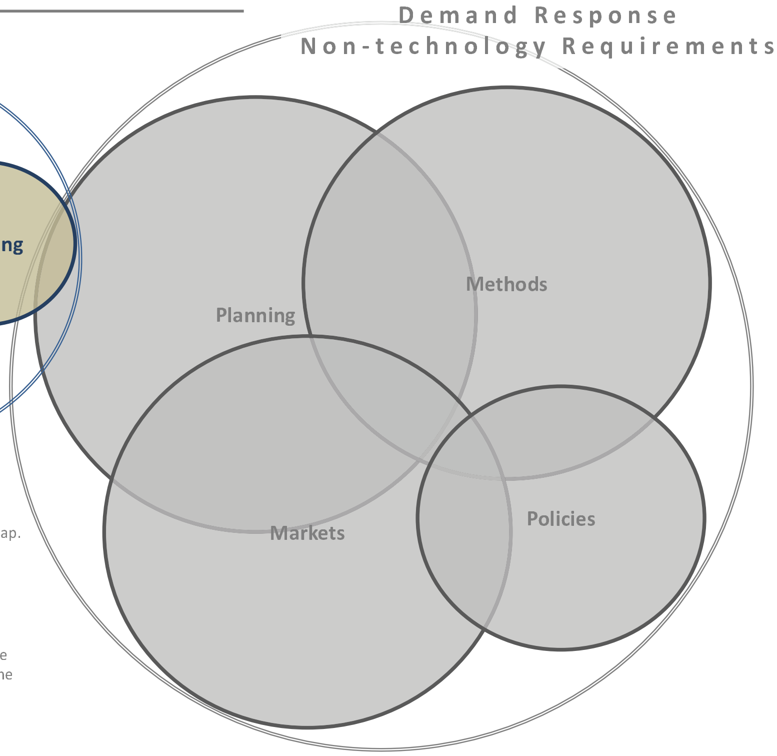
Strategy, Vision, and Structure of the Demand Response Technology Roadmap



See following pages for specific technology roadmaps within each Research Area

Demand Response Roadmapping: Representing the Distinctions Between and Interrelationships Among Critical Functions





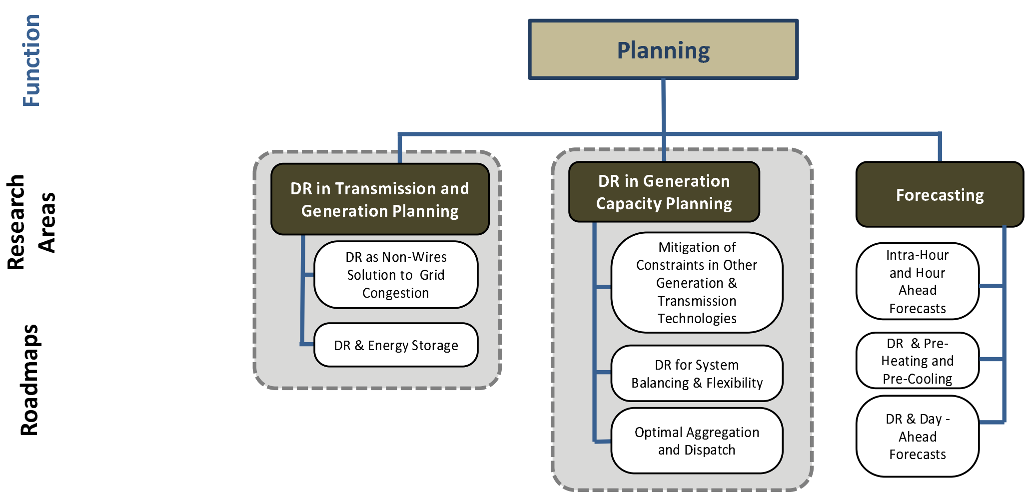
Purpose:

Provide an alternate way to conceptualize critical DR research areas that would fall within BPA's DR Technology Roadmap, critical areas that would fall outside, and areas that would overlap.

Assumptions:

- This is a DRAFT diagram to aid in conceptualization; titles and content of specific research areas are to be defined by DR experts.
- In certain DR applications, non-technology requirements may be more of a priority; pursuit of these requirements falls outside the purview of the DR Technology Roadmap.
- Within the DR Technology Roadmap, non-technology requirements may very well be critical Drivers or present important Capability Gaps that can best be overcome by developing technologies (products or services).

Handout



Shading indicates Research Areas selected for the 2014 project phase

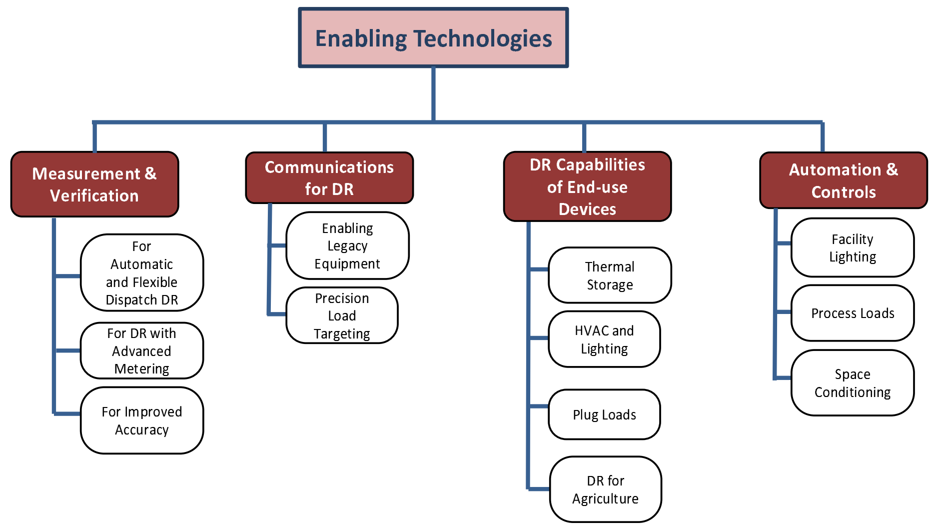
Handout

Back to Table of Contents

Function

Research Areas

Roadmaps

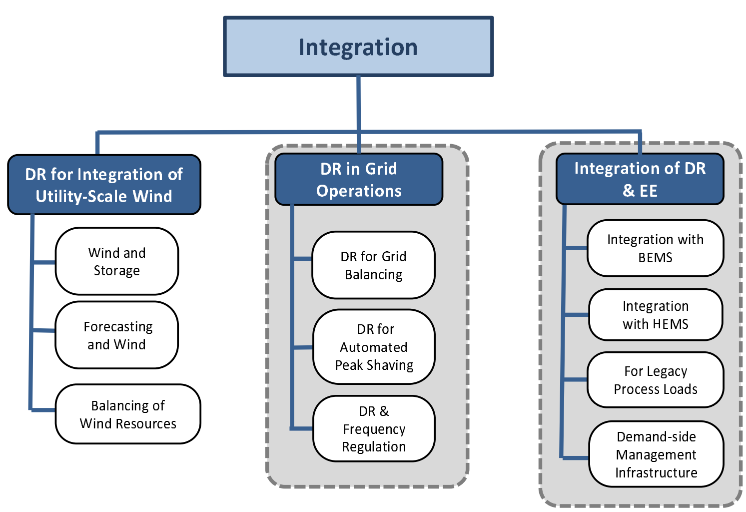


Handout

Function

Research Areas

Roadmaps



Shaded areas denote Research Areas selected for the 2014 project phase

Handout

Research Area Definitions

Planning

Technologies that facilitate, support, streamline, and otherwise enable and enhance transmission and generation planning

DR in Transmission & Generation Planning involves the use of DR technologies in planning processes to address existing and forecast transmission and generation needs. These technologies assist grid operators in load management and enable improved system reliability and provide imbalance reserves. While providing improved system flexibility, they may also enable participation in energy imbalance markets.

Forecasting for DR involves technologies used to develop forecasts for day-ahead, hourly and sub-hourly system loads as well as balancing requirements for capacity. Examples include technologies that assist in pre-chilling and pre-heating for thermal storage, assisting in predictive control of DR assets, as well as providing improved responsiveness to month-ahead, day-ahead, or hour-ahead notification periods.

DR in Generation Capacity Planning involves the use of DR technologies in the generation capacity planning process to address BPA capacity needs, such as hydro-generation imbalance, and may also provide BPA grid operators with other ancillary services..

Shading indicates Research Areas selected for the 2014 project phase

Handout

Research Area Definitions

Enabling Technologies

Technologies that enable demand response communication, controls, scheduling, confirmation, billing, and related activities

Automation and Control refers to technologies with the ability to respond dynamically to signals from the grid or grid operators to control loads (INCs or DECs). This includes DR enabled devices capable of responding to sub-hourly notification and devices that provide for automatic economic dispatch. These technologies increase customer engagement and provide reliable load reductions.

Communications for DR refers to the technologies and software protocols (BPA requires OPEN ADR2.0b) used to trigger, respond to and measure DR events. These technologies enable load augmentation in response to peak demands including technologies that are smart meter enabled. Utilizing two-way communications these technologies enable assets to provide additional capacity. These devices provide for cyber-secure economic dispatch and can facilitate participation in energy imbalance markets.

DR Capability of End Use Devices refers to technologies that respond to dynamic signals from the grid or grid operators to control loads (INCs or DECs) such as DR-enabled automatic lighting controls, automated thermostats, and devices for both electrical and thermal energy storage.

Measurement and Verification for DR refers to the technologies and protocols using the OPEN ADR 2.0b framework to measure and verify the load reductions or increases (INC/DEC) dispatched during a DR event, in comparison with an established energy use baseline at a site or aggregation of sites. Examples include technologies that provide measurement and verification of DR events and event participation rates in addition to devices to assist in accurate DR event settlements.

Handout

Back to Table of Contents

Research Area Definitions

Integration | Technologies that enable the integration of other components, systems, software, generation assets to facilitate demand response

DR in Grid Operations refers to the technologies that can enable DR in response to load forecasts or dynamic grid energy or capacity requirements to allow system operators to respond to generation imbalances and increase system flexibility. These technologies typically involve a DR management system that is also useful for grid regulation. This definition applies to 10 minute-ahead, hour-ahead and day-ahead time horizons.

DR for Integration of Utility-Scale Wind refers to the use of DR technologies in addressing hydro-generation imbalances associated with oversupply of wind energy. These technologies assist in addressing generation oversupply and intermittent generation and provide grid regulation services that aid in wind integration.

Integration of DR and EE involves technologies used at a site or group of sites to maximize energy efficiency and enable demand response. These can include integrated home and business energy management systems that enable DR and provide a real-time determination of available capacity, automatic lighting controls, and automated thermostats and plug load controls.

Shading indicates Research Areas selected for the 2014 project phase

Handout

Building Upon Workshop 1 Output

EE and DR Team

"Requires a common software platform for communications between the end load and the utility. This would improve situational awareness and provide information on load shapes for the customer, the utility and BPA"

"For EE and DR C&I customers are still the low hanging fruit"

"There are still questions about DVR and CVR as either a EE or DR asset"

"Who has priority when a customer/utility/system operator wants to trigger an asset?"

"increased use of variable capacity drives will impact DR markets. As they become more popular, the effects on load shapes will resemble the difference in load shapes between regular resistance water heaters and new heat pump water heaters."

Building Upon Workshop 1 Output

DR in Grid Operations Team

"Discussed the potential in using DR for INCs and DECs as a fast response tool as well as the need for improved forecasting with better resolution"

"To grid operators looking to trigger DR events its always location, location, location"

"What is the ability of the DR asset to cycle off and on as a means of providing cost effective flexibility"

"DR provides for regulation of loads as well as frequencies."

" We need cost effective telemetry to intersect with our AGS system."

"NERC Critical Infrastructure Protection requirements could present big challenges for this research area"

Building Upon Workshop 1 Output

DR in Generation Capacity Planning Team

"There is a need for aggregated dispatch of DR to optimally control hydro-generation and river flows as well as to deal with transmission congestion"

"Operators need a real-time display of DR availability and a means of valuing it"

"DR can be used as a CO_2 free capacity hedge for variable energy resources"

" An EIM or Security Constrained Economic Dispatch (SCED) market with CAISO will make DR more valuable and eventually begin to influence BPA's Open Access Tariff"

"As a substitute for DR, BPA is currently using power contracts for some of its capacity needs"

Back to Table of Contents

Building Upon Workshop 1 Output

DR in Transmission & Generation Planning Team

"Planners dislike uncertainty and DR has plenty of perceived uncertainties"

"Planners need visibility into the amount of location specific DR that's available to defer generation. They also want to know how DR can positively effect system use"

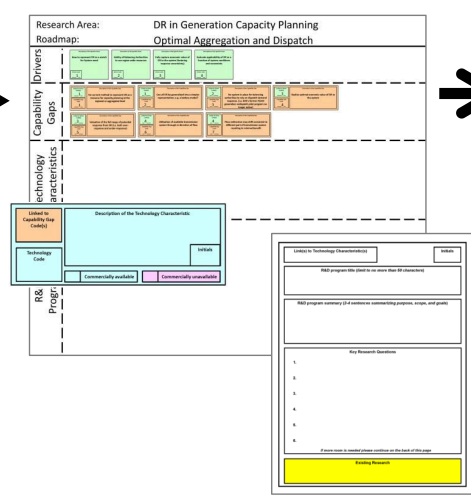
"There are perceptual barriers among planners about DR, they are skeptical of it and need to see it demonstrated"

"We could look at dis-aggregating DR loads to identify the best loads to curtail, there are also vehicle to grid storage opportunities that we should consider"

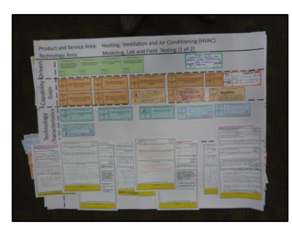
Workshop Process

Convening Workshops

Recording Content



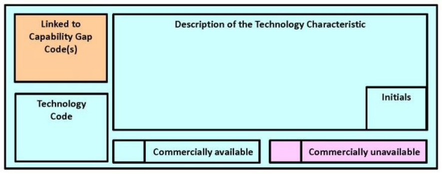
Processing Content



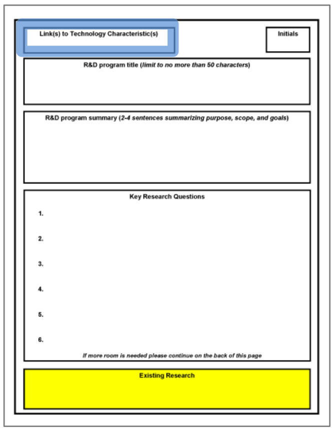
Post-workshop processing: PSU, EPRI

Workshop Materials

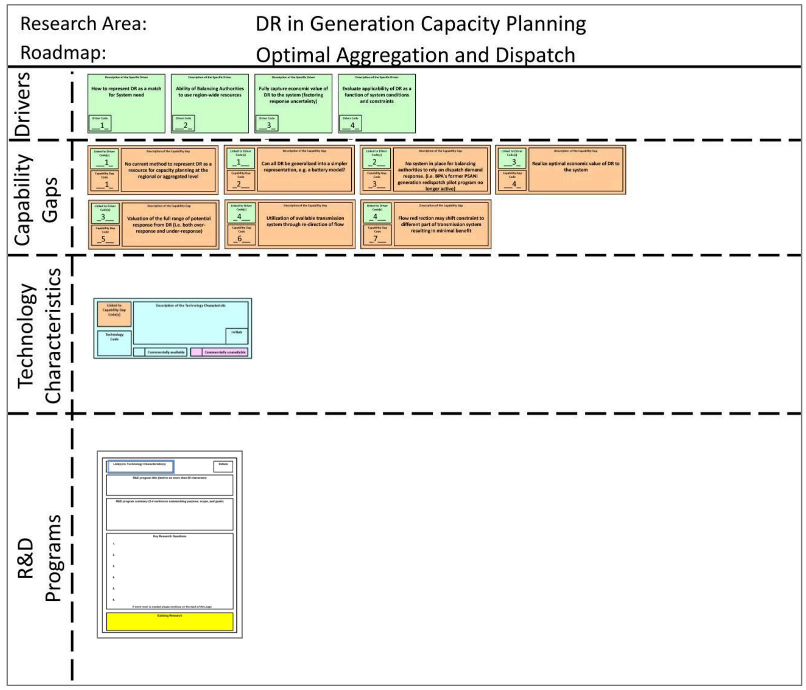
Technology Characteristics Cards



R&D Program Cards



Posters

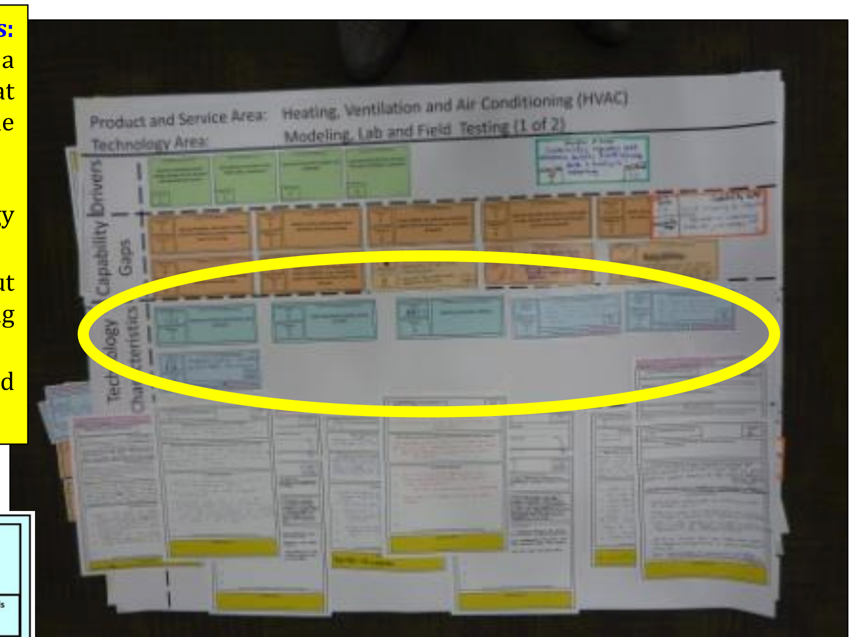


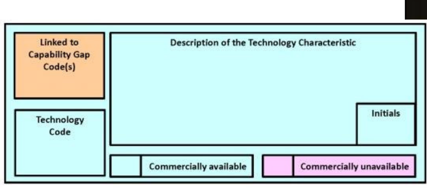
Workshop Materials: Technology Characteristic Cards

Technology Characteristics: Specific technical attributes of a product, model, system, etc., that are necessary to overcome Capability Gaps.

To be included in the technology roadmap, these will either be:

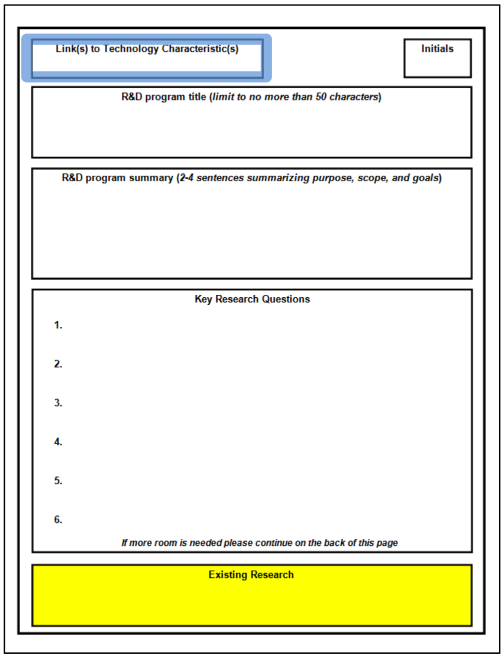
- **Commercially Available** but facing technical barriers needing to be addressed; or
- **Commercially Unavailable** and needing to be developed.





Back to Table of Contents

Workshop Materials:
R&D Program Cards



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

1.

2.

3.

4.

5.

6.

If more room is needed please continue on the back of this page

Existing Research

- ✓ For each **Technology Characteristic** card, provide content on the **R&D Program** card:
  - R&D program title
  - R&D program summary
  - Key research questions
  - Existing research—if applicable and if known
- ✓ Provide your initials.
- ✓ Provide linkages to one or more **Technology Characteristic** cards, as appropriate.
- ✓ Tape the **R&D Program** card on the relevant poster.

Preliminary Team Assignments

DR in Gen Capacity Planning

- Shawn Chandler
- Mohamed El-Sharkawi
- John Goodin
- Ben Kujala
- Mary Ann Piette
- Anurag Srivastava
- John Wang
- Ram Narayanamurthy
- Rob Pratt

DR in Grid Ops

- Farrokh Albuyeh
- Tom Brim
- Kwok Cheung
- Angela Chuang
- Gene Fein
- Ifty Hasan
- Karanjit Kalsi
- Steven Low
- Ning Lu
- Tom Osterhus
- Farrokh Rahimi

DR in T & G Planning

- Diane Broad
- Erik Gilbert
- Anders Johnson
- Sila Kiliccote
- Dmitry Kosterev
- Yuri Makarov
- Kaj Skov Nielsen
- Omar Siddiqui
- Aidan Tuohy
- Frank Brown

DR & EE

- Chen Chen
- Ryan Fedie
- Carl Linvill
- Ebony Mayhorn
- Alex Papalexpolus
- Manisa Pipattanasomporn
- Jill Powers
- Alison Silverstein
- Megan Stratman
- Jianhui Wang
- Heather Williams

Preparation for Day 2

9:00 a.m.	Welcome Recap of Day 1 and preparation for Day 2	James Hillegas-Elting, BPA
Objective 3	**Prioritize R&D Programs and prepare for team presentations**	
9:15 a.m.	Review Day 1 output Prioritize R&D Programs **Focus Question:** On a three-tiered scale, what is the relative importance of each R&D Program toward realizing the linked Technology Characteristic(s)? *(Green = High, Yellow = Medium, Red = Low)* Prepare for Team Presentations	Dr. Tugrul Daim, PSU Workshop Participants
10:15 a.m.	*BREAK*	
Objective 4	**Team presentations: Summary insights and conclusions**	
10:30 a.m.	Team presentations & group discussion (cross fertilization) **Focus Question:** What are the key takeaways, summary highlights, and most important lessons-learned that the team discussed and documented?	Workshop Participants
11:00 p.m.	***WORKING LUNCH**: Continue team presentations & group discussion*	
	Continue working on Objective 3	Workshop Participants
11:45 a.m.	Wrap-up & Next steps	James Hillegas-Elting, BPA
12:00 p.m.	Adjourn	

Prioritization

One dot per person per R&D Program card for all roadmaps within each Research Area

Green = High

Yellow = Medium

Red = Low

What this prioritization will achieve:

This “bottom-up” prioritization from experts at Workshop 2 will be correlated with the May 2014 “top-down” prioritization from BPA’s DR Executive Sponsor Team and the mid-level prioritization from selected BPA technical subject matter experts.

These three prioritization scores will be combined into an aggregate score that will help BPA’s DR Team and the agency’s Technology Confirmation and Innovation Council determine what will be included in the FY 2016 solicitation (March 2015).

Results will be made public when the roadmap document is published in March 2015

Back to Table of Contents

Next Steps

- Roadmap team will transcribe & process (PSU) and review (EPRI) Workshop 2 output.
- Draft document will be refined and published by November 15; email notification to all contributors to solicit critical comment.
- Internal and external feedback incorporated into draft, Dec. 2014–Feb. 2015.
- March 2014 version published on the BPA Technology Innovation website as part of the FY 2016 solicitation.

Closing

Thank you for participating!

Contact Info:

Thor Hinckley
503.230.5533
hinckley@bpa.gov

James V. Hillegas-Elting
503.230.5327
jvhillegas@bpa.gov

Backup Slides

Determination Regarding the M&V Research Area

On June 13 three subject matter experts in Workshop 1—Ammi Amarnath (EPRI), Ken Dragoon (Ecofys), and Will Price (EWEB)—identified some Drivers and Capability Gaps in this Research Area.

On June 30 the Project Sponsor Team—Terry Oliver, Lee Hall, and Ryan Fedie—reflected upon the Workshop 1 output and discussed whether or not there was enough of a pressing regional need to include this Research Area as part of Workshop 2.

On July 2 Thor and James brought this topic to Omar Siddiqui (EPRI). They agreed with the Project Sponsors in concluding this ought *not* to be part of Workshop 2, for the following reasons:

1) the extensive M&V now going on at other utilities for multi-million dollar DR transactions, meaning that the M&V is robust enough for these parties to agree on the economic exchange;
2) the subject matter experts in Workshop 1 found two priority M&V needs: a) analytics to determine the baseline, and b) M&V through advanced metering infrastructure (AMI)—however
   a) baseline determination is more a matter of policy and guidelines than of developing new products or services through technology R&D;
   b) M&V through AMI is an important topic for technology R&D for many utilities in the U.S., so EPRI has recently committed significant resources to this—however, this topic is not as important in the Pacific Northwest because there is still relatively little AMI infrastructure in the region;
3) therefore, given DR Roadmap project resources and priorities in the Pacific Northwest, the team will not include the M&V Research Area as part of Workshop 2; they will, instead:
   a) include Workshop 1 output as part of the final deliverable,
   b) consider this Research Area for future phases of DR technology roadmapping work for the agency,
   c) potentially collaborate with EPRI on future roadmapping work in this area, and
   d) keep up-to-date, as needed, on the technology R&D that EPRI is doing.

Back to Table of Contents

Workshop 1

Objective: Within the Research Areas selected by the Bonneville Power Administration's DR Executive Sponsor Team, identify strategic Drivers and Capability Gaps (defined below).

Schedule: One-day by-invitation workshop on June 13, 2014, in Portland, OR.

Participants: Senior-level leaders and operations managers involved in developing and / or implementing corporate strategy (including public policy, regulatory compliance, business development, etc.), as well as having familiarity with the role played by technologies to achieve strategic goals in demand response, smart grid, integrated demand-side management, and related areas. These experts will provide input on the "strategic" levels of the roadmap critical in developing a resource that directly supports key business objectives.

Workshop 2

Objective: Within the Research Areas selected by the DR Executive Sponsor Team, identify the Technology Characteristics and R&D Programs (defined below) that address strategic Drivers and Capability Gaps identified during Workshop 1.

Schedule: Two-day by-invitation workshop on September 18–19, 2014 in Portland, OR.

Participants from Utilities, National Laboratories, Universities, R&D Organizations, Non-Governmental Organizations, Vendors, etc.: Subject matter experts from within and beyond the Pacific Northwest to develop the "tactical" roadmap content—the Technology Characteristics and R&D Programs—that can help meet the "strategic" Drivers and Capability Gaps. These experts will include engineers, operators, researchers, academics, etc., with direct and deep knowledge and experience in envisioning, developing, and analyzing technologies, models, algorithms, systems, etc.

Demand Response Technology Roadmap

Workshop 2

Oregon State Bldg. Room 1B
800 NE Oregon St.
Portland, OR
September 18–19, 2014

Workshop Participants

Demand Response in Transmission and Generation Planning

1) Diane Broad (Oregon Department of Energy)
2) Frank Brown (Bonneville Power Administration)
3) Anders Johnson (Bonneville Power Administration)
4) John Wang (ABB)
5) Rob Pratt (Pacific Northwest National Laboratory)
6) Aidan Tuohy (Electric Power Research Institute)

Demand Response in Grid Operations

7) Farrokh Albuyeh (Open Access Technology Int'l, Inc.)
8) Tom Brim (Bonneville Power Administration)
9) Kwok Cheung (Alstom Grid)
10) Angela Chuang (Electric Power Research Institute)
11) Ifty Hasan (Entouch Controls)
12) Karanjit Kalsi (Pacific Northwest Nat'l Laboratory)
13) Sila Kiliccote (Lawrence Berkeley Nat'l Laboratory)
14) Steven Low (California Institute of Technology)
15) Ning Lu (North Carolina State University)
16) Kaj Skov Nielsen (Siemens)
17) Alex Papalexpolus (ECCO International)
18) Anurag Srivastava (Washington State University)
19) Jianhui Wang (Argonne Nat'l Laboratory)
20) Le Xie (Texas A & M University)

Demand Response in Generation Capacity Planning

21) Shawn Chandler (Bonneville Power Administration)
22) Erik Gilbert (Navigant)
23) John Goodin (California Independent System Operator)
24) Ben Kujala (Northwest Power and Conservation Council)
25) Tom Osterhus (Integral Analytics)
26) Omar Siddiqui (Electric Power Research Institute)

Integration of Demand Response and Energy Efficiency

27) Chen Chen (Argonne Nat'l Laboratory)
28) Ryan Fedie (Bonneville Power Administration)
29) Carl Linvill (Regulatory Assistance Project)
30) Ebony Mayhorn (Pacific Northwest Nat'l Laboratory)
31) Ram Narayanamurthy (Electric Power Research Institute)
32) Mary Ann Piette (Lawrence Berkeley Nat'l Laboratory)
33) Manisa Pipattanasomporn (Virginia Tech)
34) Jill Powers (California Independent System Operator)
35) Farrokh Rahimi (Open Access Technology Int'l, Inc.)
36) Alison Silverstein (N. American Synchrophasor Initiative)
37) Megan Stratman (Northwest Requirements Utilities)
38) Heather Williams (Opower)

Work Group Report-Out Transcription

Transcription of audio recording by James Hillegas-Elting and Thor Hinckley. The initial transcription draft was sent to all workshop participants to allow them to clarify or expand upon the information they provided during the workshop, and this final version incorporates the feedback received.

Note: The transcription contains references to green, yellow, and red "dots" or stickers. These are the three colors of dot stickers workshop participants used to provide their evaluation of relative importance of each R&D Program card to the linked Technology Characteristic card(s). This prioritization exercise is explained in more detail, and the results summarized, in the roadmap document itself.

Demand Response in Grid Operations

[Transcribed by James Hillegas-Elting]

Angela Chuang: Alright, so what we did was we looked at the R&D cards with more green dots than others, so they're higher priority. We have a lot of cards, dozens of cards, but that's how we narrowed-down the higher priority R&D. So that's what we're going to focus on. We put blue dots on those [higher priority] cards.

So for the three sub-areas here under Grid Operations, we had originally been given these three sub-areas. It ranges from "DR for Automated Peak Shaving," and this is not just full generation peak, but also grid peak, ok, so congestion would fall under there as well. We're saying this is for economics as well as for full system capacity peaks as well.

Here, this is "DR for Grid Balancing." This is going beyond what EPRI calls "DR 1.0" to "2.0" where it's not just about when the loads are on, turn them off, but it's also when they're off, how do we turn them on. So, DR for grid balancing in both directions.

And then the third sub-area is "DR for Frequency Regulation." How that is different is that this is the really fast response, following signals on the order of seconds. This is to change every second, and this [DR for Grid Balancing] is on the order of minutes or longer, so that's how these two areas are differentiated. So I'll start here and work backwards.

For DR for Frequency Regulation, there are two R&D cards that had mostly green dots—more on them than the other colors. They both address—and the operative word here is "cost effective"—telemetry, they both address that gap. So, they're titled "Cost effective communication and control," and the other card is titled "Development of low-cost telemetry." That's the common theme here, and that's the major gap, because if you want to do DR for frequency regulation, it has to be cost effective and it has to have these requirements. One of them being the very costly telemetry requirement to meet. So the R&D programs focus on how to do that, and looking at the different communications technology makes sense. In this first—"Cost effective communication and control" research program—also looking at *developing* low-cost telemetry, even going to that step, not just looking at what's available.

So I'm going to move on to the next R&D area. Does the group have anything else to add here? [*No response.*] Ok.

Now, for DR in Grid Balancing, we had five cards that had more green dots than other colors. Here are some similarities, we'll see some patterns and similarities in R&D programs, because DR, if you can use it for, let's say frequency regulation, you can use it for a lot of other services. That was a common theme: We need to advance the research agenda so that the same resource or asset for DR can be used for different services. How do we do that? One way is to have a common information model, so that in the system that the planners and operators use, they know exactly what this asset can really do. So to do that we're going to have to characterize DR capabilities not just for services but also for temporal—you know, when the services are available. In our cognitive information model we're having a hierarchy of information that is passed, we can imagine, not just from the RTO / ISO down to the aggregation level, but also to the asset level itself—the resource and then the asset level. So, a common information model that can have pieces in it that can be transferred, and as you go to higher levels in the hierarchy, aggregating that information so that it's presented in a way that's useful and actionable to the operators and planners. So, this information model is a common theme in that area.

We also said another R&D program is integrating transmission and system analysis. There's a lot of advancement at the transmission level, but as we have more resources on the distribution level, to be able to leverage them, we need to have power flows that also take into account, for example, what's on the distribution side. So, we have to move beyond and do this integration for the analysis in doing T and D.

Another important research program is the valuation of DR. DR can have a different price, right. With respect to other resources, like storage and variable energy resources. Obviously, DR can be used for many different purposes or use cases across the electricity value chain, so how are we going to value DR for transmission, distribution, capacity, all of that? And then how can we then decide where and when to use it, and how to use it relative to other conditions? The value of storage and variable energy resources on the grid. So, DR valuation was very popular here.

I wanted to move on to DR characterization. I did mention a little about characterization before, but that's very important: Tools for characterizing what DR can do, so that we can use DR in grid ops planning and markets in an optimal way. Especially for grid balancing, that's the focus of this sheet.

And then the final R&D program is addressing cost-effective controls for mass market connected loads to provide grid balancing services. This is important. The operative word here is addressing cost-effective controls. One way to do that is to look at what loads are already being deployed, that are already connected—not by utilities, but by end-use customers, mass-market customers like residential and small commercial. They are already going to their local retail store or local installer to procure these loads, and these loads, if they had already the connectivity and controls built into them, they could be leveraged also for grid purposes. That's a much more potentially competitive increment in cost than buying a whole storage system just for electricity purposes, like buying a battery. So this could address cost effectiveness if we can work on the controls that need to be added. And these loads are already being procured by mass-market customers.

Before I transition, were there any other comments from the group on these R&D cards? [*No response.*] Ok.

Moving to "DR for Peak Shaving." We had many cards, we had like a dozen or so cards, and about four of them floated to the top with more green dots than other colors. There's a similarity in theme here. The first R&D program has to do with addressing the gap on DRMS [DR Management Systems]. This Capability Gap is "Integrated dispatch systems for multiple DR programs." They're integrated. This came out in a lot of cards that were addressing that particular gap, and were addressing it through enabling these hierarchical or advanced demand response management system, or DRMS, with certain capabilities and characteristics. Like, these DRMS systems will know locational information of where the DR assets are and resources are. That's critical if you want to use DR beyond your total generation system peak more to a locational basis, so that's a key characteristic addressed.

We can get our academic community here to add further detail, but a distributed grid intelligence type of paradigm, where you have different layers in a hierarchy of intelligence—you have your aggregation-level intelligence, then you have your resource-level, and then finally your asset-level. Someone mentioned like a plug-and-play: If you had the ability to communicate between these different levels and then the proper information being passed between the levels, about the DR capability, then you can truly optimize in the decision of which resources to dispatch for what purpose. There's this concept of interoperable DR programs, so the same programs for DR being used for different purposes. To do that we need this information model.

The characterization of DR came up again: The ability to optimize based on what assets and resources are out there.

We also talked about real-time monitoring and optimization systems—so that's extending DRMS.

And demand response uncertainty modeling and power system operations. These systems for analysis modeling dispatch, they need to be able to take into account uncertainties, especially with additional variability on the system from the variable sources of generation as well as what the loads are doing.

One more card here is also about hierarchical systems, but it adds into it this concept of the interoperability being addressed through the information models and—help me out here, there's one thing I'm missing from the last card—how it takes the hierarchical system and advances it even further.

Steven Low [?]: You should consider the timing issue, and dynamic flow.

Angela Chuang: Timing, yeah, that's right. Did I miss anything, would you like to highlight anything?

Ning Lu: Yeah, only one thing, that actually we have this agreement that baselining the demand response resources is very important, because for you to actually measure how much you can get from demand response programs, you need to have a baseline you can follow, so that's one thing I want to highlight.

Angela Chuang: Ok, thank you.

James Hillegas-Elting: Ok, we have about three minutes for Q&A. And please state your name before you ask the question so we can be sure to document that. [*No response.*] So that group covered everything that needs to be covered? No one else has anything to question or contribute?

Rob Pratt: I'll raise an issue. I may have heard you address this, but I'd like you to maybe address it a little more in-depth, and that is the notion of having a demand response asset, or resource, but then dispatching those assets to try to achieve multiple—maybe these three—but multiple objectives, you know, the extent to which these are mutually exclusive, and the extent to which a given device or resource can do a couple of them, or all of them at the same time, is very important in terms of cost effectiveness. Did you guys discuss that, or do you want to elaborate on that issue at all?

Angela Chuang: Yeah, we didn't go into detail, but this idea that temporal considerations of what's available when, and benefits being already committed to other services at that time can also produce, you know, sub-services. That's also a market question, a market design and rules question. In some markets you can do capacity and other services in the same temporal slice of time, but in other markets they have different rules. So, yeah, we didn't go into market rules, but that's a good point.

Alex Papalexpolus: From the market perspective, like a typical conventional resource, there are some clear parameters that will—based on the bids—will determine if it provides a product in this market, or in this market, or in the other program. For example, DR can participate in the day-ahead energy market, or it can participate in the non-spin day-ahead ancillary services market. Where it will actually produce, where it will get, depends on the business structure of that resource, and the associated software that's providing the structure. In other words, when it submits the bids, it doesn't need to do anything else, because the prices will be produced from the software reflect the opportunity costs, the foregone costs if it doesn't participate in the specific market. So it's not going to lose money. But that's the way the methodology could be developed. So they can participate in multiple markets to provide multiple products, but what actually will happen depends on clear direction at the business structure.

Rob Pratt: So, I'm not sure I fully agree, if I understand your answer, because I would submit that you could do peak shaving and, say, fast regulation at the same time, with the same resource, the same hour. You know, I set my overall consumption at some level, and then I go like this [*hand gestures*] within the hour.

Alex Papalexpolus: Sure, peak shaving could be in real time.

Rob Pratt: Bidding in one market shouldn't necessarily mean I won't win a bid in the other market too.

Alex Papalexpolus: Yes you can, in the other market, of course, absolutely. You have a day-ahead award, in real time you will be dispatched—it's a different market. So, yes, you will participate in both. But within the *same* market, you can participate in multiple products, as long as your capacity allows you to participate in those multiple products, you can win awards in multiple products.

Rob Pratt: Got it.

Erik Gilbert [?]: I think before you can put it into markets, I think one area that you need to study is characterizing the different types of loads themselves and what can they actually do in the context of whatever business function they're serving, right, so one of they key issues for something like balancing, say, non-spinning reserves is you need it potentially for many, many hours a year, whereas for peak shaving many fewer hours, so, can you get someone to sign up with that particular service. So I think characterizing that for different types of loads is probably a really key question, before you even can look at where you will sell it.

Alex Papalexpolus: Absolutely, that's one of the issues we have addressed.

James Hillegas-Elting: Ok, we've got time for one more quick question if there are any.

Rob Pratt: So, one related topic that relates to the capacity planning area is that in the Northwest we have these distribution entities that are really independent of, say, Bonneville, and we don't really have a formal market structure, and so the issue becomes if they install DR down there, and they're using it to manage their monthly peak ratchets in their Bonneville rate structure, then the resource may have already been dispatched when all of a sudden Bonneville Operations calls for it, and then it's been used up. Not only is there need to share that information, but as a capacity planner, how can you count on it if it might, in fact, been used up? These are important issues that are a little twisted in the region compared to most parts of the country.

James Hillegas-Elting. Ok. With that, thank you very much for the presentation and the questions. Which of the next three groups would like to go next?

Demand Response in Generation Capacity Planning

[Transcribed by James Hillegas-Elting]

Ben Kujala: We can go next. Ok, so I'm just going to do kind of a high-level outline, but I'll lean on my group members to jump in and go into details. We had DR in Generation Capacity Planning, which obviously has overlap with a couple of other areas as well, but we tried to keep to the intent of the original Drivers and Capability Gaps that were set up there, and let that define the categories for us.

So, we had the one overview of mitigation of constraints in, basically, G [Generation] and T [Transmission] technology. There were several things that we really covered in this one. One was a CO_2-based dispatch—so, in a production cost model sort of setting, as well as a system expansion, to be able to do an optimization for CO_2 emissions in both of those settings rather than, you know, post-hoc sort of analysis of the CO_2 emissions.

A method for valuing flexibility—not necessarily valuing it or paying it once it's dispatched or moved, but actually valuing the inherent capability of demand response resource—or, honestly, a hydro resource or any other resource—its capability to be flexible In other regions you would have a capacity market, so research a method to make that flexibility something that is paid for in a capacity market. In this region it's a little harder, but the general concept is, how do you value the actual flexibility of generator or a demand response program ahead of time, as you're giving it a capacity payment?

The other thing that we had was some sort of agent-based simulation of DR kind of in a transmission system for integration planning. The idea being that you have all kinds of moving parts that it's too complex to model the entire system, so a way to integrate DR as an element in an agent-based system, or a systems-dynamics sort of system, where you have each node doing its own thing. So, how do you put DR into that construct, and how do you look at in a model that can do long-term capacity planning—sort of like Energy 2020 or some of the other system-dynamic models, maybe like Andy Ford's work[1]—how do you put DR into that structure and actually get a model that's appropriate for it?

So that was our "Mitigation of Constraints in Generation and Transmission." Does anyone have anything to add on that particular category?

[1] Dr. Andrew Ford, Professor Emeritus, Washington State University. See http://public.wsu.edu/~forda/.

Rob Pratt: Nope, good job.

Ben Kujala: Ok, so, then we had "DR for System Balancing and Flexibility." Once again, this is sort of under this capacity planning umbrella. Basically you guys [the Demand Response in Grid Operations work group] also had that, but it wasn't how you do that in a capacity planning setting. So, our perspective was always, how do you make these decisions well in advance of actually procuring and operating the resources, and once again we had to allow the Drivers and the Capability Gaps to set out what we were going to examine. What we really came down to is, first of all, in the capacity planning—I think you guys [the Demand Response in Grid Operations work group] also mentioned this for your area—but really it's very important for this particular area is, we need some sort of potential study that says, this is the amount of DR that's available that *could be* used for balancing or flexibility. If we did not have potential study, then, I mean, we couldn't figure out how much to purchase, basically. We need the bounds on what is capable of being done.

The other thing that we put in there is some sort of pilot that could be scaled to show that DR is a resource for capacity planning. We felt like there's some inherent distrust of the capacity value of DR within the current utility capacity planners in the Northwest: Having somebody be able to come in and look at a particular program that has gone on for a very long time that is showing a consistent resource that is dependable, that can be there, and is as available as any generator, through a long-term pilot that continues to grow, that would be a very useful thing.

And then the last thing was a lot of elements of estimating the duration and response of demand response resources, especially characteristics of the different programs. There's a large distributed program, a lot of individual pieces moving, whereas if it's a big single industrial load, they have different statistical characteristics in response, you would have different forced outages, or kind of implied forced outages; we would have different potential communications problems. Coming up with an actual distribution of response, because oftentimes it seems like you would call demand response programs and you would have an uncertain response. You want to be able to quantify that uncertainty so you can value it and then maybe your system planners can count on a minimum response, but you want to not lose the value of any over response.

I think that covers kind of what we had in a broad-brush in the "System Balancing and Flexibility," did I miss anything guys?

Rob Pratt: I guess I'd add one nuance, and that is that we talked a lot about uncertainty, and sort of how do you value that, how do you discount that for capacity planning. On the down side, there was a point made in the discussion that the communications system potential breakdown is another source of forced outage for DR that we need to take that uncertainty into account when you're doing capacity planning. It will happen, sooner or later, and so those kinds of things.

On the up side, we also talked about how capacity planning is based on forecasts of load growth, and somebody was saying in the region those are all sort of bubbled-up from the distribution utilities, but sometimes that load growth doesn't materialize, and so obviously DR is a hedging strategy, because you can course-correct it better than you can when you build a power plant. So bringing *that* kind of uncertainty into the analysis add value to DR, whereas the other ones are sort of discounting value.

Ben Kujala: The last category we had was this kind of "Optimal Aggregation and Dispatch," kind of once again in planning models, or that sort of structure. So, we also said we clearly need to add an element of a DRMS, or a DR management system, in there, talking about how to optimally manage the resources through a centralized system, and how would you plan for that. We had the economic value—especially economic value in the Northwest of it—so that we could, obviously, plan on how can you get the most value from DR through the region in the optimal sort of aggregation and dispatch, and who would do that. And also locational value, and that one we spent quite a bit of time on, talking about how you would look at potentially putting-in a structure where you would have DR zones and have response within a zone be the product, so that if you had a third-party aggregator, they could give you a response within, say, Zone A or Zone B, but they would have potentially different prices if there's congestion in the zones.

The last thing we had in there was a way to start using DR in planning for transmission system operations—so, get it into a power flow model, see if you can use it in your ATC [Available Transfer Capability] or in your RAS [Remedial Action Scheme], sort of, approaches to transmission planning. Basically have a power flow model that can dispatch DR for system congestion into either, you know, one of the production ones—Power World or PSLF [Positive Sequence Load Flow] or something like that—instead of having DR be something that's looked at ahead of, pre-processed or post-processed, have actually a bus-level dispatch of DR for transmission system needs. At least be able to study it. Obviously, that's probably a precursor to transmission operators trusting it.

Those were kind of the big, overall, categories that we had in capacity planning. Anything to add on to that? [*No response*] Ok. I guess we are ready for questions.

Alex Papalexpolus: Your second area, DR for flexibility, how do you value flexibility as a capacity resource longer-term, if you are in an environment with no markets, where the value is not in the market, let's say, its value is as a result of the market? Did you look at the possibility of coming up with the characteristics of an aggregate DR resource in order to, basically, take the balance of the mass market when you aggregate DR, small DR resources? So you can come up with a value of flexibility, even come up with measurements like aggregate ramp, equivalent of a generation ramp, from aggregate, you know, small DR programs, aggregate start of time, all that stuff comes into play to come up with a value, and you look at those aggregate attributes that we need to come up with to do the valuation of flexibility.

Ben Kujala: I think we put out an R&D program saying "look for a value of flexibility," I think that would definitely have to be one of the characteristics of it, but I think what you're referencing is kind of like what Enbala[2] does, and PJM, that sort of ability to aggregate a bunch of different loads to make a real frequency-level response, even though the individual responses aren't necessarily instantaneous. It's, I think, an element of the study that needs to be handled, but also we had, in the Drivers and the Capability Gaps, a high mention of hydro, and how you can integrate hydro and DR as flexible resources together, and so I think what we were aiming at more was kind of a general—like, how would you, in a capacity expansion world, try to pay something more if you can get flexibility out of it, and set up some sort of hierarchy for that? So, it's not even just in the operations time frame of how you're dispatching it, it's before you even get to the part of having the programmer trying to figure out how you're going to dispatch and get that frequency. How do you pay a flexible DR program in order to encourage it to be the DR program that is purchased versus the DR program that does not respond with the same flexibility or, honestly, versus a generator that does not respond with the same flexibility? If you can get more flexibility out of a DR program you should get a premium to a generator that can't move.

Ning Lu: I have a question regarding uncertainty. I think it's very nice for you to address this uncertainty. My question is, have you actually discussed who's going to observe this uncertainty? Because if you did and you actually say, "Ok, if you can't provide this service, then I don't need you to be the service provider," and then from the planning side, you could actually make the service provider to give him the guarantee that you don't have uncertainty, you might be in our program, right? So, that's my question: This is for BPA making this roadmap: will you do that from a top-down level? Like, you just tell these service providers, "if you can provide this five megawatt reduction, then provide that to me, and then I don't need that uncertainty from my side."

John Goodin: I share the same perspective. It should be from the bottom-up, rather than BPA trying to assess uncertainty, and de-rate—that's from the bottom-up—and this is the benefit of a market—you put that responsibility, that onus, on the providers, that you give me a schedule, or bid of a certain amount, and I'm going to go to the bank on that you're going to deliver that, and if you don't, you're going to get penalized, or some sort of uninstructed energy

[2] Enbala Power Networks, http://www.enbala.com/.

penalty payment, or whatever it is. But it's nothing that you worry about, you put that on them. And if they deliver capacity in a planning horizon, again, they're expected to deliver it. There's no de-rate that BPA has to do, because that responsibility is on that provider to make sure that they deliver that product to you.

Ben Kujala: Yeah, I think the other thing is to be careful that you're putting things on equal footing. Obviously, in a capacity market, if you have a traditional thermal generator you can't one-hundred-percent guarantee all the time that that is going to be available, so you need to make sure that your measures of *certainty*—which is not really certain even in the traditional generation—are similar at least. You should hold DR to the same standard.

Alex: Of course, if a generator does not show up, when it got paid the payment would be revoked. There are compliance requirements. So there are penalties in the case of the generator, too.

Ben Kujala: Right, and I mean every capacity market is different. Obviously generators do need to do maintenance at some point, they can't be 100 percent available.

Alex: They internalize that in their products that they provide. They should deliver it.

Ben Kujala: But I do think that that sets up a situation where you have DR likely to get a very conservative response. Especially if you have something in the residential DR as compared to a large industrial load. With DR for a large industrial load you can have a guaranteed response, you know your loads really well, you know your process and you know how you can change it. If you're sending out an Internet signal to a whole bunch of thermostats or water heaters or something like that, then what's going to happen is you're going to bid a very conservative amount into the capacity market. You want to make sure that as you look at the value of that type of program you also estimate the over-response if you're expecting the providers to be conservative in that way, and get the value of the response into whatever calculation you're making. Certain DR programs are not going to have a certain megawatt value for their response, but in a capacity market bid they probably would have maybe fifty percent of what their response is, or something like that.

Ning Lu: Can I ask a second question? This is a follow-up to that first question I asked. I know that in this roadmap we didn't really mention design a DR program evaluation criteria or just requirement. Like when a generator is providing the service, it has a certain limit you have to meet. Without that, you wouldn't be qualified to bid into that market, right. So if the roadmap actually specified that, then for these service providers, when they design their DR program, they would take these technical requirements into consideration. Therefore, eliminate the uncertainties for providing baseline. So I think that if you, from this level, and then set, let's say, for peak shaving, that you would have to do this and that, then when we design these—either researcher or provider—we would take these as a constraint, therefore design more efficiently our offerings.

Ben Kujala: I guess, from my perspective, when we're talking about, capacity planning, we want to be able to examine a wide range of possible things. And then that will help us guide what actually goes into the implementation, and that is probably more in the implementation frame, where you're talking about how you design your contracts, how you design the way that you're going to integrate DR into the DRMS sort of system. But in the capacity world, in this sort of precursor, we want to have every potential range, and then if we see there's a lot of value in something that does not have the certainty that you're talking about, but the costs are much lower because of things like the monitoring that you guys already discussed, then maybe that's something that we should encourage. And I think that's the world that we've used in this region for energy efficiency and we'd probably want to try to take that success and see if it also translates into DR.

James Hillegas-Elting: Ok, we're out of time with that unless anyone has any really quick comment to button it up. Otherwise, like I said, once we get out the draft and such, critical comment is more than welcomed, and we can add to it—we're more than happy to do that. But, in the interest of time, let's go ahead now and shift quickly to lunch.

[Short break for people to pick up their lunches and return to their tables.]

DR in Transmission and Generation Planning

[Transcribed by Thor Hinckley]

This group focused on some of the Capability Gaps identified earlier. One of the primary concerns is raising the confidence levels of Transmission (Tx) planners in these DR assets. In regard to raising planners confident the group came up with some ways to get beyond “Rainbows and Unicorns” by testing and demonstrating projects of at least 25 MW. Also the group was interested in helping to define the confidence intervals for these different technologies, while providing useable controls to Generation Operators (GO) and Transmission Systems Operators (TSP) to increase their confidence and build a strong business case that these resources are tested, proven and reliable.

The group supported the concept that the BPA should explore alternative financing and contracting methods for these technologies to enable smaller utilities to utilize them. The group discussed Energy Storage (ES) devices and technologies and whether these are worthwhile as R&D project. There are some potential large scale energy storage technologies in the NW that could be adapted to DR.

Other types of need identified by the group include research on the various types of loads by customer, load shapes, and the development of supply curves. From a planning perspective, operators need a spatial representation of where the DR opportunities are, the quantity available and when they available and for how long. Typically, Tx planners look at the highest load hour of the year when designing their systems and to change those plans by including DR assets, requires a very high level of confidence that those assets will perform. The group discussed how this information on DR can move into the Tx planning models that these planners rely on.

A member of the audience spoke of the need to accurately determine the resource characteristics needed and quantifying the costs for those resources to allow BPA to use RFP’s to obtain them. Rather than focusing on determining the DR capabilities of individual devices e.g. water heaters or other thermal storage systems, technology is showing us that in the future DR will be provided by aggregation of all types of home devices, offered up into the market for whatever specific type of DR service is required. We should only be offering out the operational requirements hours, ramp rate, availability of what we want the market to provide.

The group talked about BPA purchase of using DR to acquire balancing reserves, which has been acquired through bi-lateral agreements. He doesn’t believe that aggregators would be willing to develop an application specifically designed to acquire balancing reserves required to meet BPA’s obligations.

Integration of Demand Response and Energy Efficiency

[Transcribed by Thor Hinckley]

In the residential arena there were some overarching themes as to what aggregators can acquire and supply from residential loads. It was noted by a member of the group that tests with electric water heaters were inconclusive and it was difficult to quantify when and if the assets were to become available. Behavioral studies around DR and EE is needed to understand the different incentive programs and how they can increase participation in EE and DR aggregator programs. This group was also interested in the architecture for automated DR to improve its capability to be used as a flexible and reliable resource, also of interest was Cyber security, and the interoperability of DR assets.

Integration of DSM infrastructure: the two areas here that rose to the top were load shape research and better coordination of EE load shapes and DR capabilities. There is a need for better software and algorithms to determine locational marginal pricing within the Pac NW and how that interacts with communication protocols for OpenADR 2.0. The group identified the need for better understanding of DR capabilities from customer end use loads for better predictability of and increased visibility of DR assets for Tx and Generation planning.

The group identified the need for better integration of DR with BEMS and HEMS controls, and establishing parameters to let an efficient market place work, as well as what can you do to add flexibility to the various types of DR assets . Also, identified as highly important were internal DR control systems and interoperability standards, as well as the need for commissioning for DR and EE, and training EE professionals on DR and capacity markets.

The group also discussed the need to design effective programs to determine end use loads for different devices as well as understanding what is happening at the whole building level including the use of distributed generation and how that would interact with DR and interact with OpenADR2.0 communications protocols .

To allow HEMS and BEMS to be widely used, there is a need for low-cost and low-power software and hardware devices for HEMS and BEMS that address interoperability issues of integrating heterogeneous end-use devices/load controllers that use different communication technologies and protocols, and that can talk to electric utilities or third-party aggregators through an open standard. In addition, cost/benefit of deploying HEMS and BEMS should be studied and evaluated.

To the points in the paragraph above, Dr. Manisa Pipattanasomporn also suggested the following sources:

M. Kuzlu, M. Pipattanasomporn, Senior Member, and S. Rahman, "Hardware Demonstration of a Home Energy Management System for Demand Response Applications," *IEEE Transactions on Smart Grid* 3:4 (Dec. 2012), 1704-1711.

Manisa Pipattanasomporn, Murat Kuzlu, Saifur Rahman, and Yonael Teklu,"Load Profiles of Selected Major Household Appliances and Their Demand Response Opportunities," *IEEE Transactions on Smart Grid* 5:2 (March 2014), 742-750.

Manisa Pipattanasomporn, Murat Kuzlu, and Saifur Rahman, "An Algorithm for Intelligent Home Energy Management and Demand Response Analysis," *IEEE Transactions on Smart Grid* 3:4 (Dec. 2012), 2166-2173.

M. M. Rahman, M. Kuzlu, M. Pipattanasomporn, and S. Rahman, "Architecture of Web Services Interface for A Home Energy Management System," *IEEE Innovative Smart Grid Technologies Conference (ISGT)*, Feb. 2014, pp. 1-5.

A. Saha, M. Kuzlu, and M. Pipattanasomporn, "Demonstration of a Home Energy Management System with Smart Thermostat Control," *IEEE Innovative Smart Grid Technologies Conference (ISGT*) Feb. 2013, 1-8.

Shengnan Shao, Manisa Pipattanasomporn, and Saifur Rahman, "Grid Integration of Electric Vehicles and Demand Response With Customer Choice," *IEEE Transactions on Smart Grid* 3:1 (March 2012), 543-550.