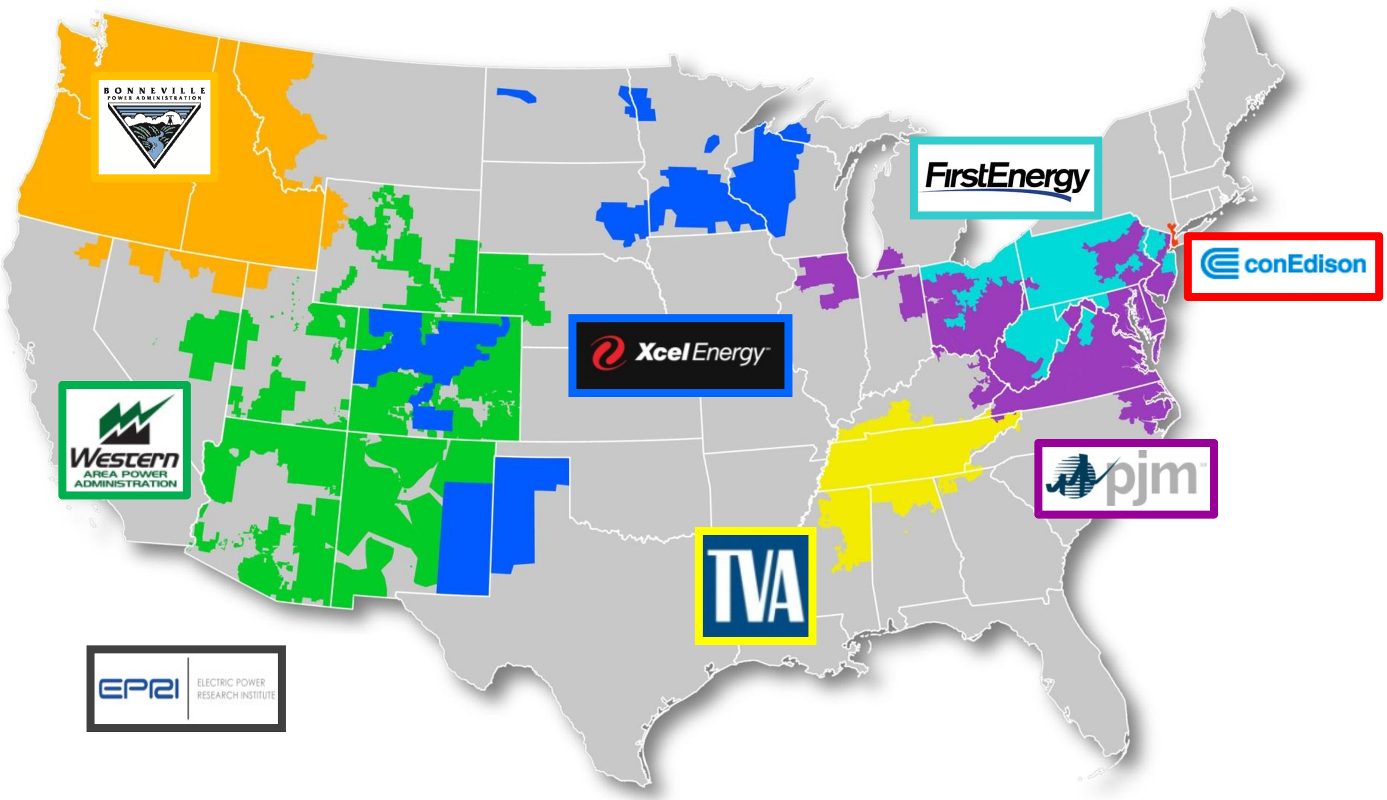
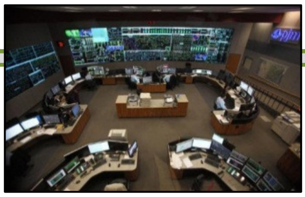
Collaborative Transmission Technology Roadmap
Appendix: Process Documents

March 2014




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.

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INTRODUCTION

This appendix contains process documents and related files that pertain to the Collaborative Transmission Technology Roadmap project. The team has made these companion documents available in the interest of providing full visibility into the project background, workshop agendas, and insights provided by workshop participants. This appendix will be updated as needed to reflect future Roadmap workshops.

Electronic versions of this appendix and the full Roadmap can be found at the Bonneville Power Administration Technology Innovation Office's page, http://www.bpa.gov/Doing%20Business/TechnologyInnovation/Pages/default.aspx.

For more information about the Collaborative Transmission Technology Roadmap or to offer revision suggestions, contact:

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SECTION 1

BACKGROUND DOCUMENTS

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At A Glance

Objective: Develop a Transmission Technology Roadmap, based on shared R&D objectives of collaborating organizations. The pilot effort will focus on 4 to 6 highest-priority technology areas, with scalable structure and process to facilitate future efforts.

Collaborating Organizations: BPA, EPRI, TVA, ConEd, Xcel, FirstEnergy, PJM and WAPA.

Core Project Team: BPA, EPRI, and Portland State University (PSU).

Schedule: March – November, 2013

Elements of Roadmap: 1) Strategic Drivers; 2) Capability Gaps; 3) Technology Characteristics and Requirements; and 4) R&D Projects/ Programs Underway Across Industry.

Reference Material: Roadmaps and corporate strategy documents from the Collaborating Organizations

Face-to-Face Meetings to Collect Roadmap Information:

1. **Kick-Off "Principals" Meeting (Duration: 1 Day)**
    a. Date: May 9, 2013 in Charlotte, NC.
    b. Objective: To arrive at 4 to 6 prioritized Technology Areas to focus on in this pilot project.
    c. Participants: Executives and senior managers from Collaborating Organizations.
2. **Workshop 1 (Duration: 2 Days)**
    a. Schedule: June 25–26, 2013 in Portland, OR.
    b. Objective: To identify strategic Drivers and Capability Gaps in the 5 prioritized Technology Areas.
    c. Participants: Senior-level staff from Collaborating Organizations with strategic expertise such as policy development, regulatory compliance, business development, etc.
3. **Workshop 2 (Duration: 2 Days)**
    a. Schedule: September 18–19, 2013 in Portland, OR.
    b. Objective: To identify Technology Characteristics and R&D Programs in the 5 prioritized Technology Areas.
    c. Participants: Technical staff and subject matter experts from Collaborating Organizations, National Labs, DOE, Universities, etc.

Deliverable: A prototype collaborative Transmission Technology Roadmap covering 4 to 6 Technology Areas will be delivered to stakeholders in November 2013.

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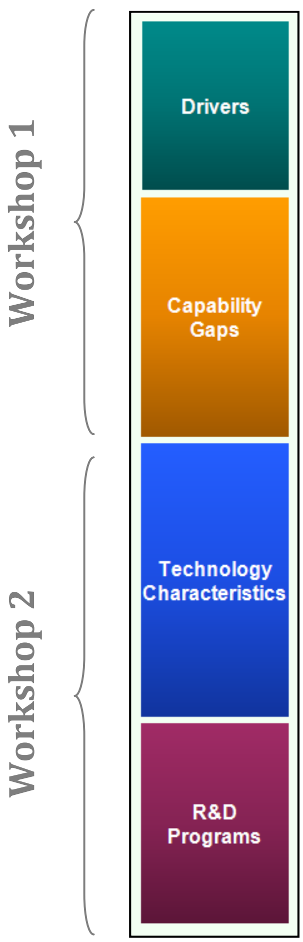
WORKSHOP 1

Objective: Identify strategic Drivers and Capability Gaps (defined below) for the high-priority Technology Areas selected at the Principals' meeting of May 9, 2013.

Schedule: Two-day workshop on June 25-26, 2013 in Portland, OR.

Participants Sought from Collaborating Organizations: 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 transmission technologies to achieve the corporate strategy. These experts will provide input on the "strategic" levels of the roadmap critical in developing a resource that directly supports key business objectives.



Drivers: Critical factors that constrain, enable, or otherwise influence organizational decisions, operations, and strategic plans. These factors can include: existing or pending regulations and standards; the environment; market conditions and projections; consumer behavior and preference; and organizational goals and culture, among others.

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

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

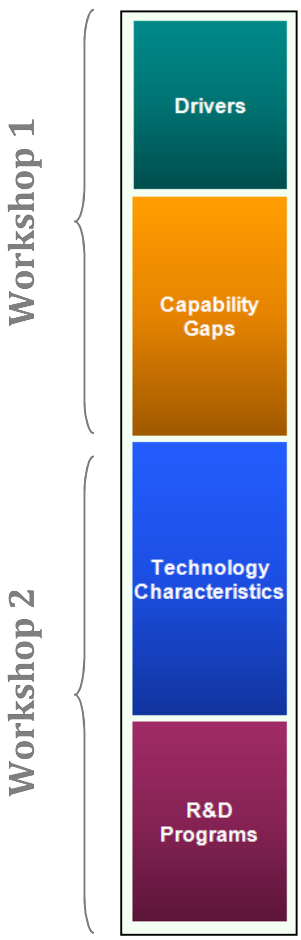
R&D Programs: An inventory of technology development and demonstration projects and programs across the utility industry to deliver the needed Technology Characteristics. The inventory represents R&D underway currently and planned in the future by utilities, RTOs, ISOs, R&D organizations, universities, national laboratories, and vendors. The R&D is intended 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. The generic abbreviation "R&D" is to be understood as including, when appropriate, design, deployment, and demonstration in addition to research and development.

WORKSHOP 2

Objective: Within the Technology Areas selected at the Principals' Meeting, identify the Technology Characteristics and R&D Programs (defined below) that address strategic Drivers and Capability Gaps identified during Workshop 1.

Schedule: 2-day workshop on September 18–19, 2013 in Portland, OR.

Participants Sought from Collaborating Organizations, National Laboratories, Universities, R&D Organizations, and Vendors: Subject matter experts (SMEs) from throughout North America to develop the "tactical" content of the roadmaps—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 transmission technologies, models, algorithms, systems, etc.



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SECTION 2

PRINCIPALS' MEETING, MAY 9, 2013

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COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP

PILOT PROJECT

PRINCIPALS' MEETING

May 9, 2013
8:00–4:00
Charlotte, NC

Agenda

Objectives

1) Review the pilot project's purpose, scope, and timeline
2) Determine 4-6 priority technology areas that will comprise the pilot project
3) Identify next steps

7:15-8:00	***CONTINENTAL BREAKFAST***	
8:00-8:20	**Welcome, Logistics, & Introductions**	Jeff Hildreth, BPA Daniel Brooks, EPRI
Objective 1	**Review the pilot project's purpose, scope, and timeline**	
8:20-8:40	**Roadmapping at BPA & EPRI**	Terry Oliver, BPA Mark McGranaghan, EPRI
8:40-9:45	**Project Tasks, Schedule, & Deliverables**	Tugrul Daim, BPA James Hillegas-Elting, BPA Bob Entriken, EPRI
9:45-10:00	***BREAK***	
Objective 2	**Determine 4-6 priority technology areas that will comprise the pilot project**	
10:00-10:30	**Review Technology Areas and Pre-work Survey Results**	Jeff Hildreth, BPA
10:30-12:30	**Discuss Corporate Priorities & Strategies**	Principals of collaborating organizations
12:30-1:30	***LUNCH***	
1:30-3:20	**Determine Priority Technology Areas**	Jeff Hildreth, BPA
1:30-3:20	***As Time Allows: Begin to Identify Drivers***	*Jeff Hildreth, BPA*
Objective 3	**Identify next steps**	
3:20-4:00	**Next steps:** Action items & Workshop 1 attendees **Closing**	Jeff Hildreth, BPA Daniel Brooks, EPRI

Participants: *Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy ▪ PJM Interconnection ▪ Tennessee Valley Authority ▪ Western Area Power Administration ▪ Xcel Energy*

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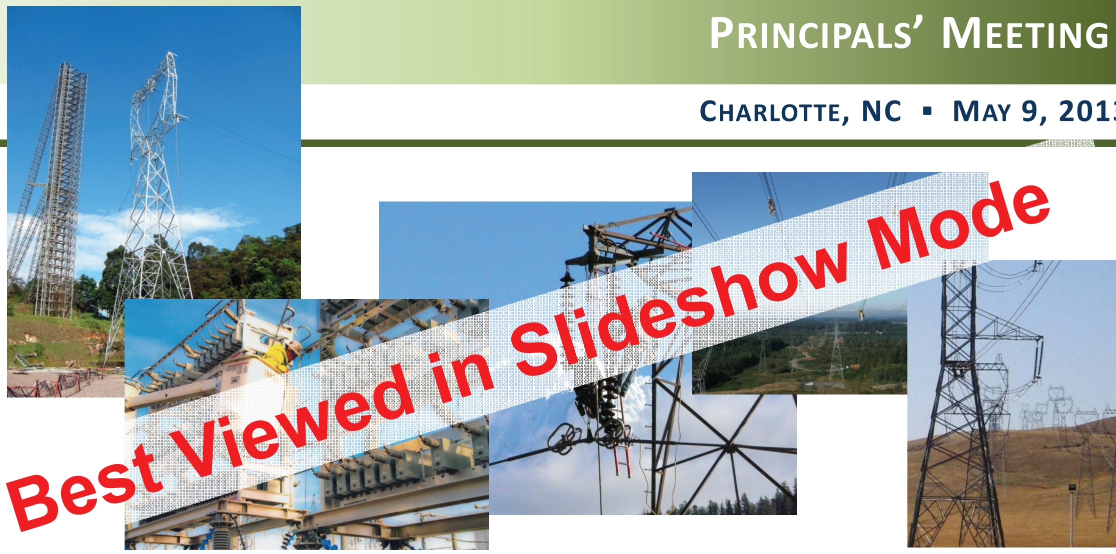
Collaborative Transmission Technology Roadmap

Principals' Meeting

Charlotte, NC ▪ May 9, 2013



Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy ▪ PJM Interconnection ▪ Tennessee Valley authority ▪ Western Area Power Administration ▪ Xcel Energy

Objectives

1) Review the pilot project's purpose, scope, and timeline
2) Determine 4-6 priority technology areas that will comprise the pilot project
3) *As time allows: Begin to identify Drivers*
4) Identify next steps

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AGENDA

7:15-8:00	*CONTINENTAL BREAKFAST*	
8:00-8:20	**Welcome, Logistics, & Introductions**	Jeff Hildreth, BPA Daniel Brooks, EPRI
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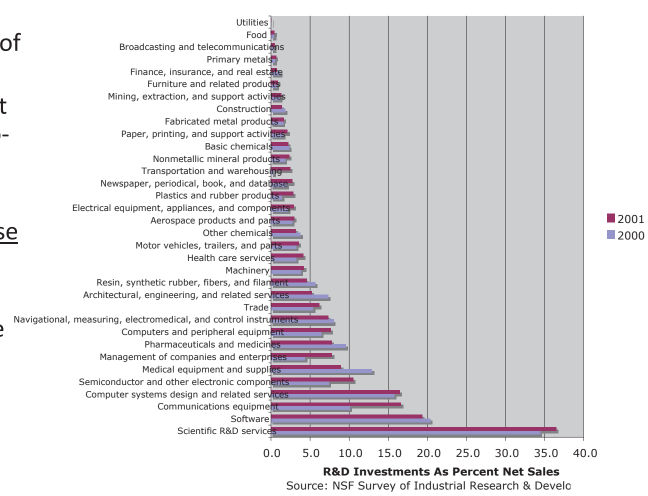
1:30-3:20	*As Time Allows: Begin to Identify Drivers*	*Jeff Hildreth, BPA*
Objective 3	**Identify next steps**	
3:20-4:00	**Next steps:** Action items & Workshop 1 attendees **Closing**	Jeff Hildreth, BPA Daniel Brooks, EPRI

ROADMAPPING AT BPA & EPRI

Why technology roadmapping?

Why Technology Roadmaps?

- Grid
  - Real-time control - limited view of events
  - Stability & oscillations - transient electrical disturbances & electro-mechanical effects
  - Efficient investments in capacity
- Energy Efficiency / Demand Response
  - Growing need for peak load management
  - Potential for end-uses to behave nicely w/o direct control
- Renewable Energy
  - Integrating 6,000 MW wind



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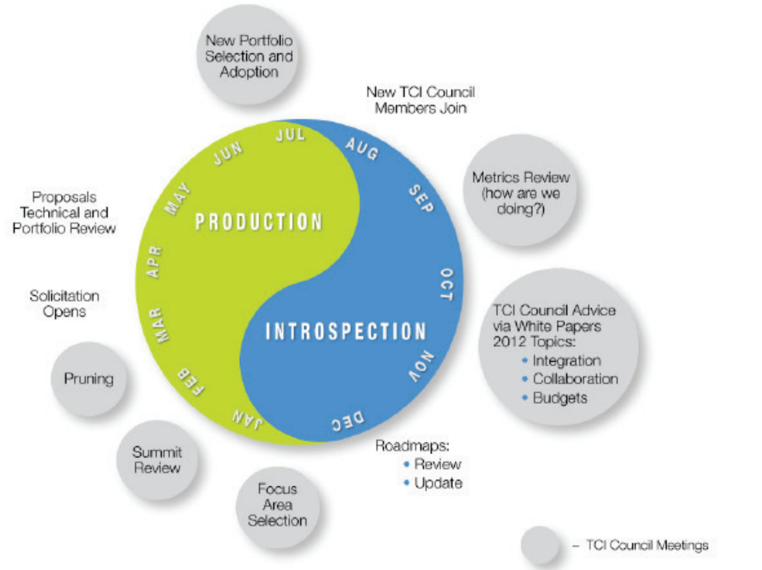
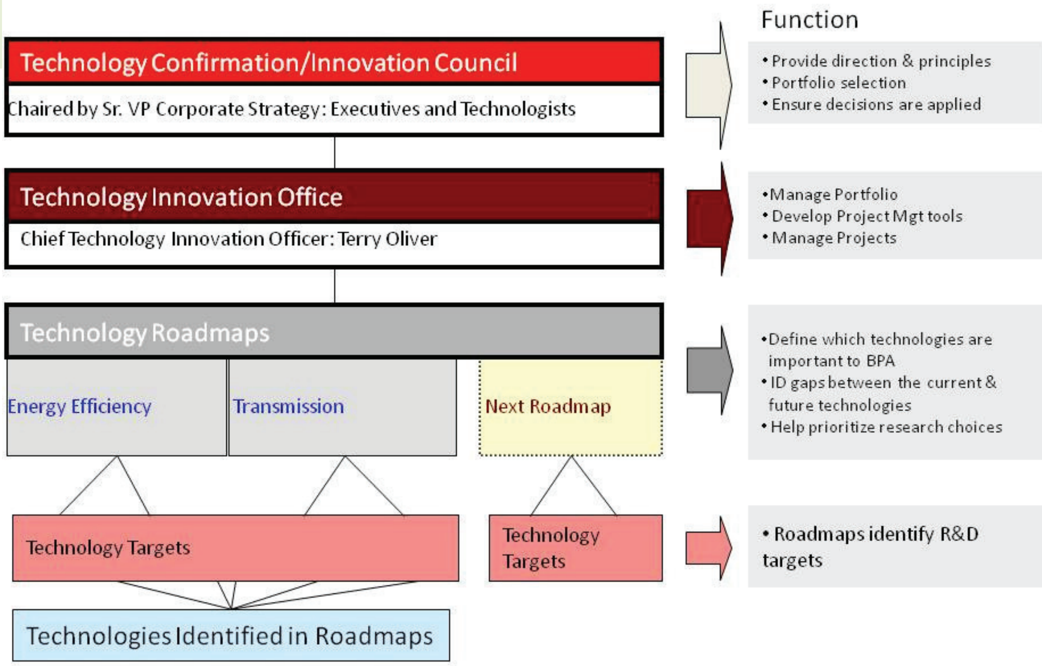
Technology Innovation Cycles



Technology Innovation Structure



Visionary of Technology Roadmap

"A roadmap is an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of the change"

Robert Galvin

Former Motorola chairman and advocate of science and technology roadmaps

Values to Organization

- Linking strategy to product plans to technology plans
- Enabling corporate/national-level technology plans
- Focusing on longer-term planning
- Improving communication and ownership of plans
- Focusing on planning with priority setting

COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP • PRINCIPALS' MEETING CHARLOTTE, NC • MAY 9, 2013

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An example from NW US

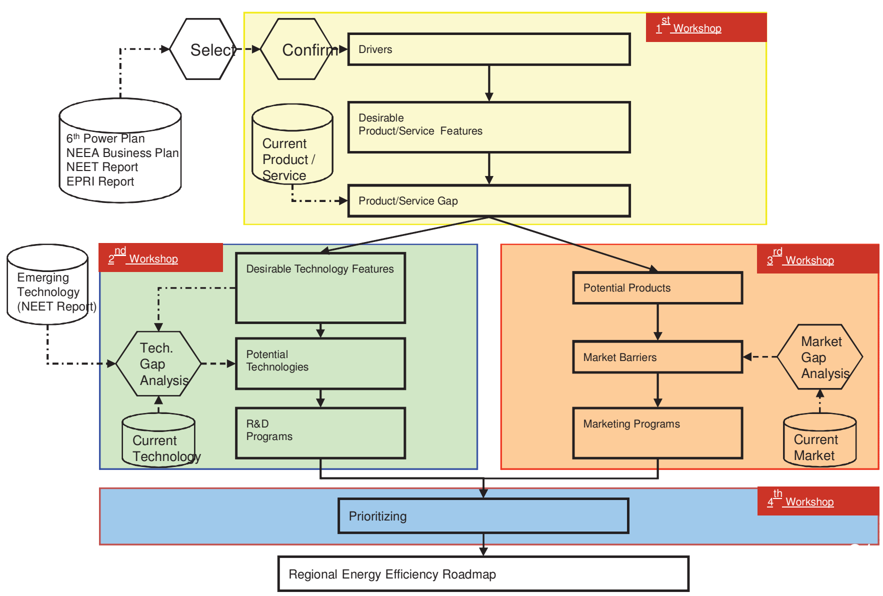
NW Regional Energy Efficiency Roadmap

- Region-wide need to develop measures identified in the Council's Sixth Power Plan
- BPA and Northwest Energy Efficiency Alliance (NEEA) was tasked to establish a formal collaboration regarding their respective emerging technology programs
- Key results of BPA-NEEA collaboration:
  1. Formation of a regional emerging technology advisory committee
  2. Development of a regional energy efficiency roadmap to help in creation of a strategic regional research agenda

1st Draft: Starting From Scratch

- Establish Roadmapping Workshop Process
  - WS1: Drivers, Products & Services, Goals
  - WS2: Technologies & Gaps
  - WS3: Market Interventions, Programs, & Other Initiatives
  - WS4: Prioritization
- Build Collaboration
  - Regional Emerging Technology Advisory Committee (RETAC) as regional owners and prioritization leadership
  - BPA to provide project management support
  - Voluntary participation by regional stakeholders
- Develop roadmap template
- Craft workshop agendas and supporting materials
- Deadline: March 2010 TI Solicitation

NW Regional Energy Efficiency Roadmap



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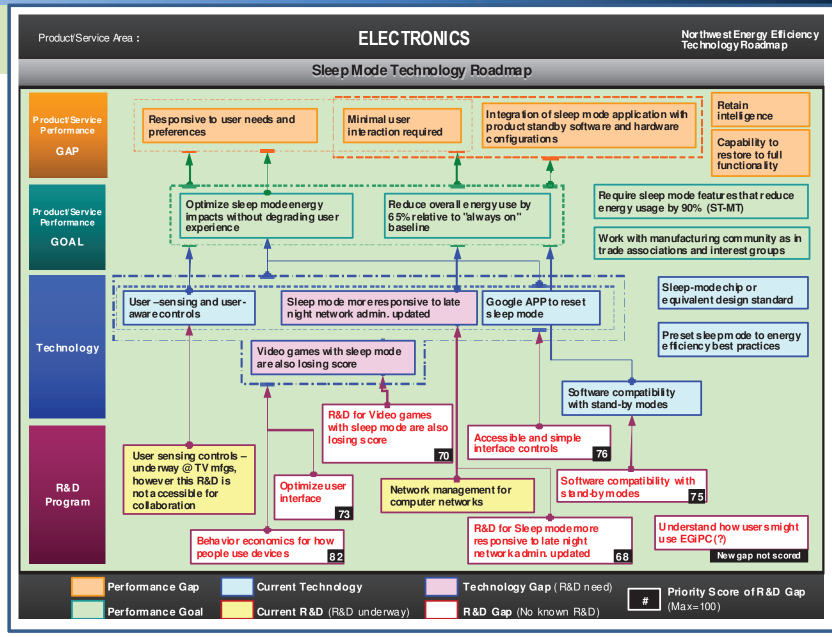
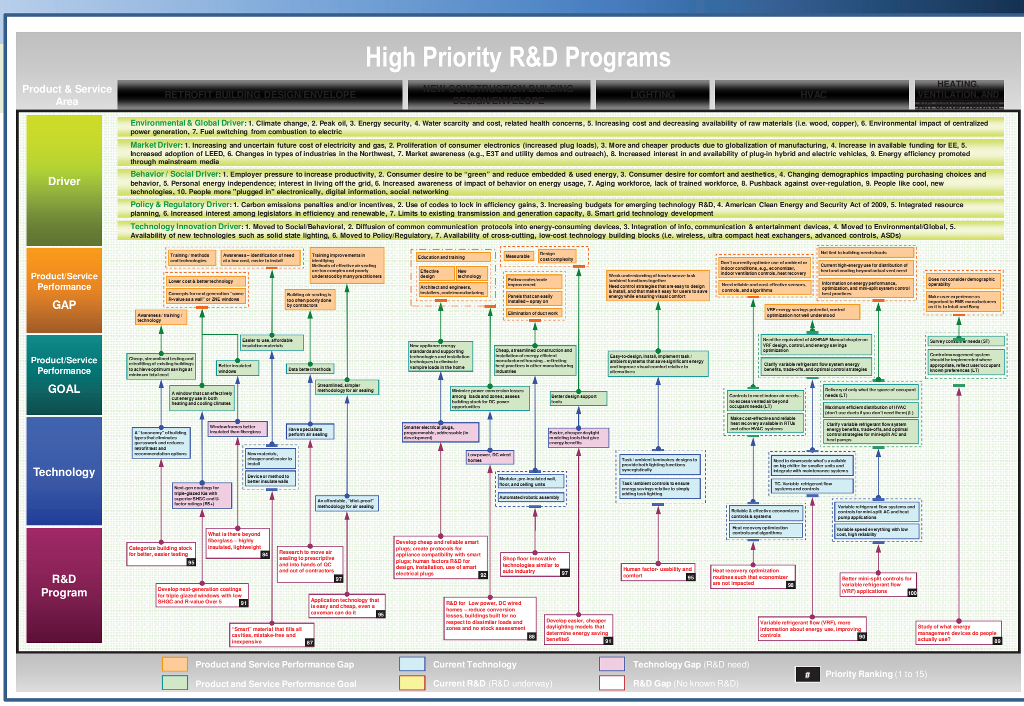
NW Regional Energy Efficiency Technology Roadmap





Key NW Learnings

- An agreed upon plan for strategic technology investments and market intitiatives
- Inclusion of all parties including government (federal and state) agencies, utilities, industry reps, national labs, universities and all related regional groups paved the way for coordinated policies and strategies
- The roadmap clearly highlighted the region's priorities, product and technology needs, gaps and investments to make to fill the gaps

National Energy Efficiency Technology Roadmap

- Held Technology Summit in Aug/Sept. of 2012
  - ~200 national/international experts for each P/S area
    - 5 roadmapping workshops in 4 days
      - Confirm/Revise existing content
      - Add short (0-5 yrs), mid-term (5-10 yrs), and long-term (10+ yrs) performance criteria
      - Prioritize P/S performance gaps
    - Interwoven with 3 days of panel presentations on existing R&D
    - Widened collaboration
    - Strengthened content of *Roadmap Portfolio*

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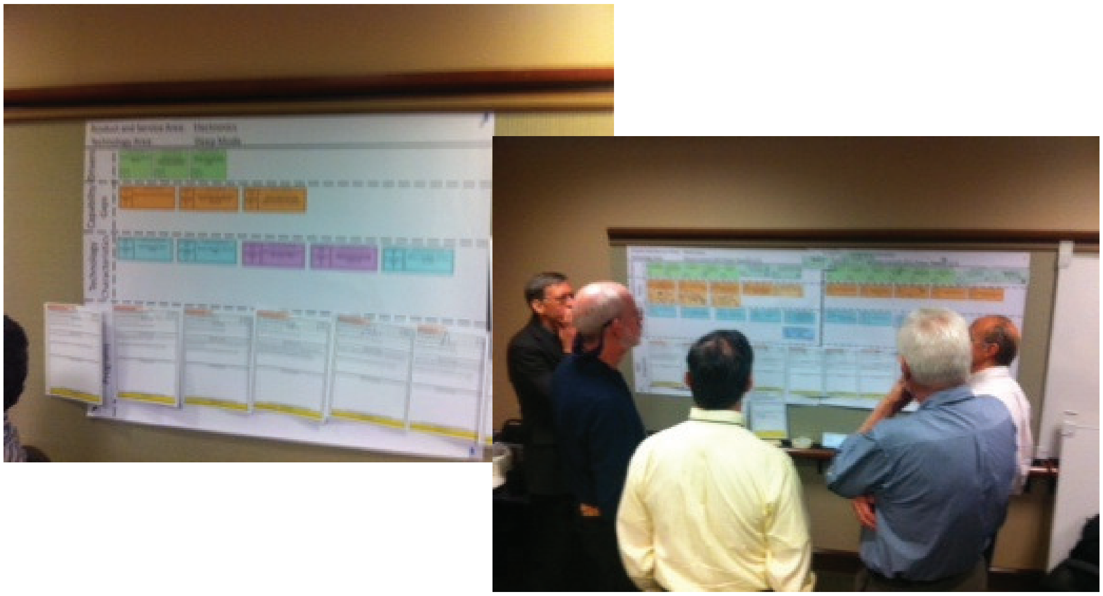
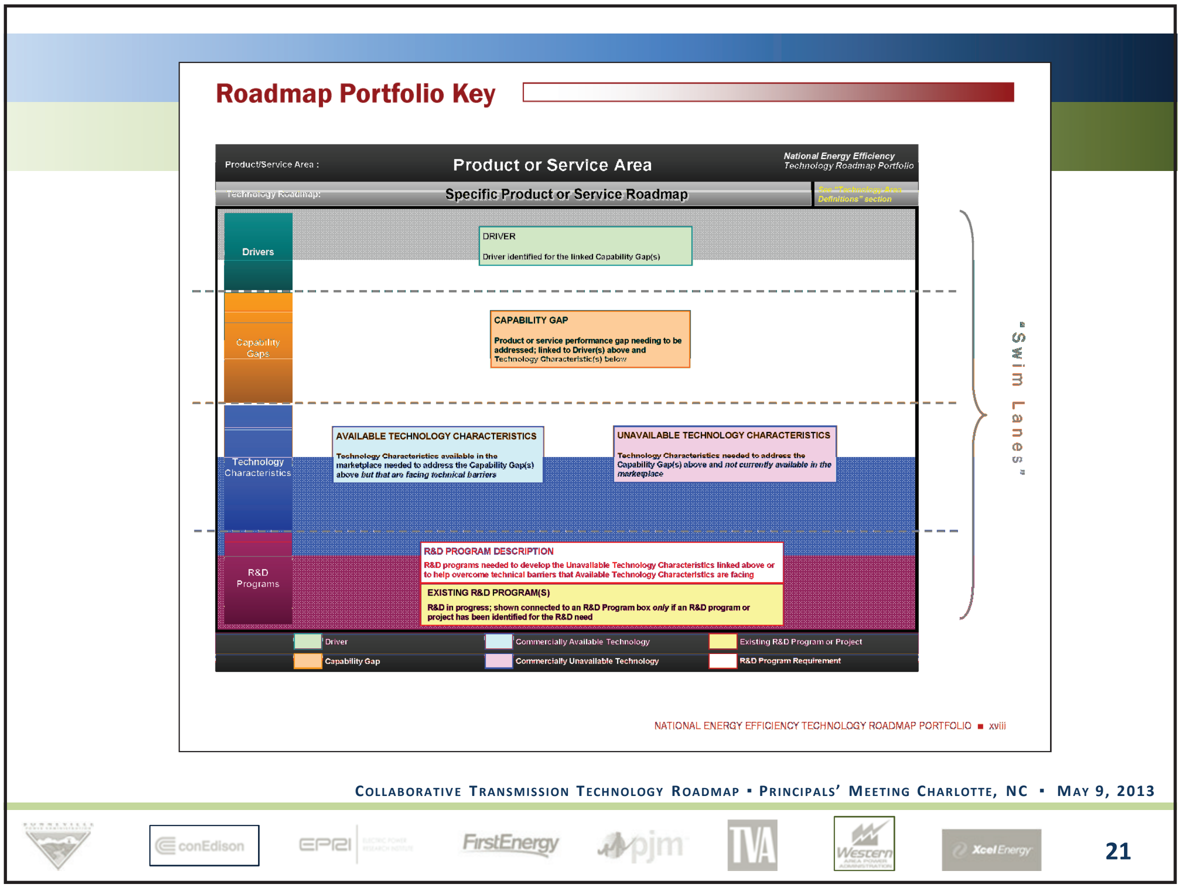
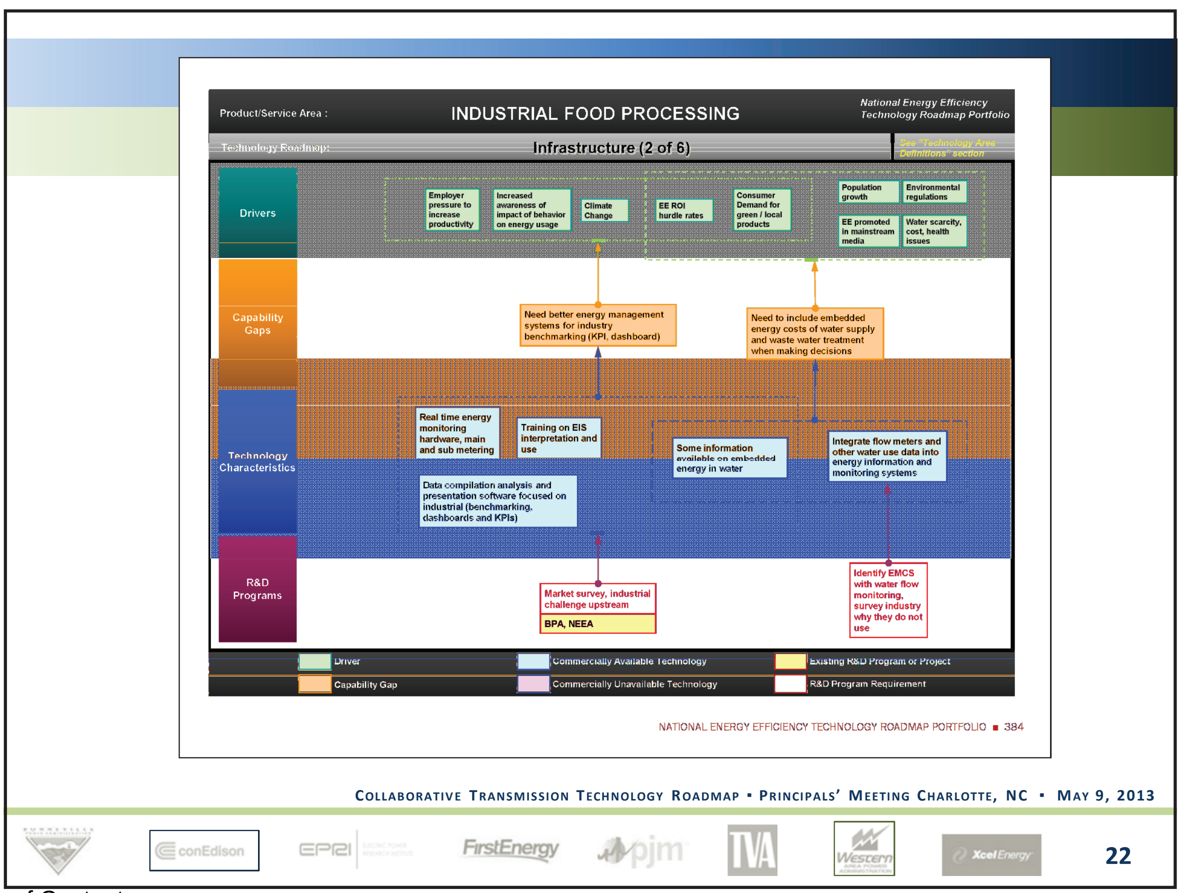


TECHNOLOGY ROADMAPPING 101

Mechanics





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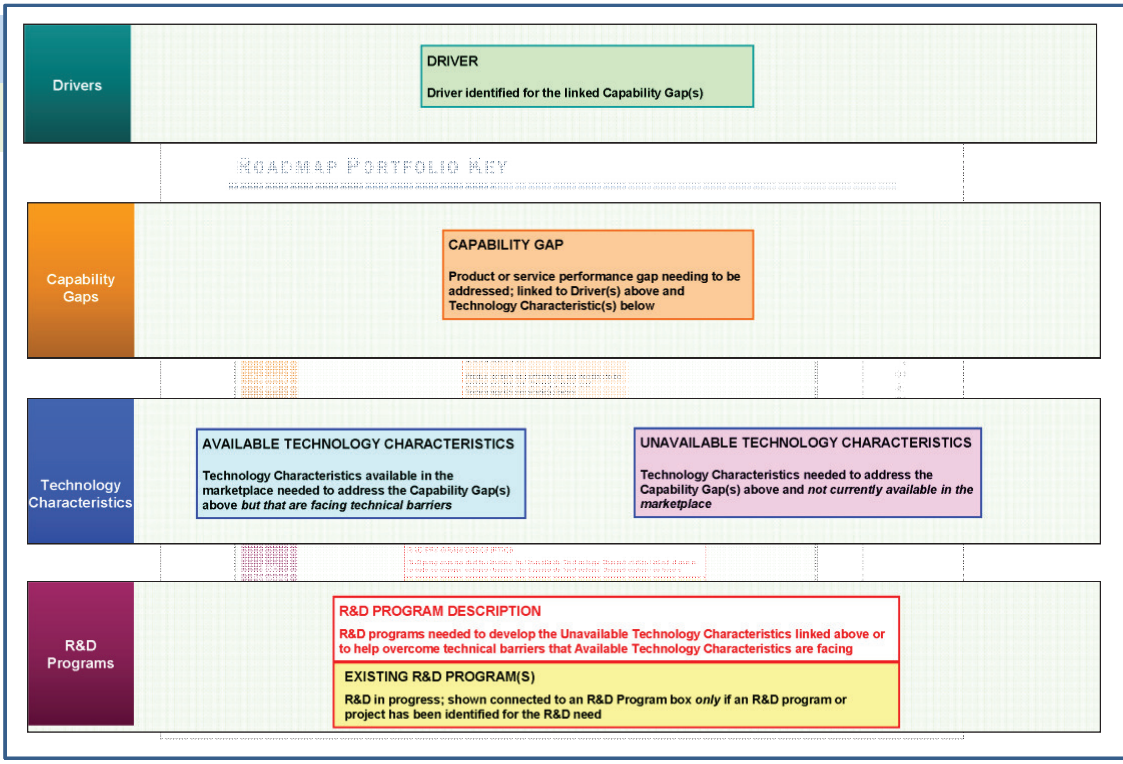
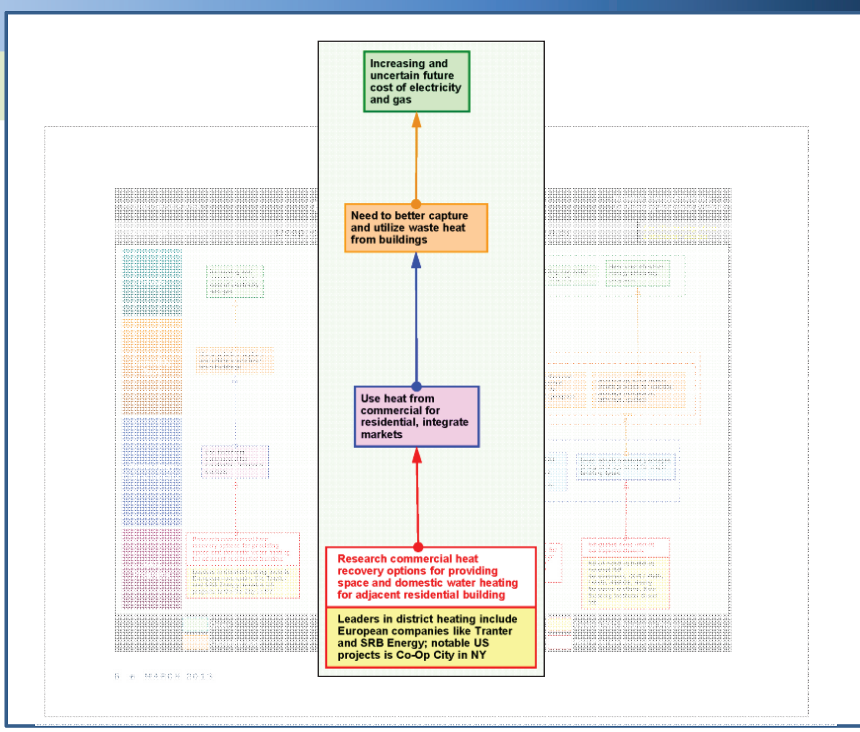

Drivers
DRIVER
Driver identified for the linked Capability Gap(s)
Capability Gaps
CAPABILITY GAP
Product or service performance gap needing to be addressed; linked to Driver(s) above and Technology Characteristic(s) below
Technology Characteristics
AVAILABLE TECHNOLOGY CHARACTERISTICS
Technology Characteristics available in the marketplace needed to address the Capability Gap(s) above but that are facing technical barriers
UNAVAILABLE TECHNOLOGY CHARACTERISTICS
Technology Characteristics needed to address the Capability Gap(s) above and not currently available in the marketplace
R&D Programs
R&D PROGRAM DESCRIPTION
R&D programs needed to develop the Unavailable Technology Characteristics linked above or to help overcome technical barriers that Available Technology Characteristics are facing
EXISTING R&D PROGRAM(S)
R&D in progress; shown connected to an R&D Program box only if an R&D program or project has been identified for the R&D need


Increasing and uncertain future cost of electricity and gas
Need to better capture and utilize waste heat from buildings
Use heat from commercial for residential, integrate markets
Research commercial heat recovery options for providing space and domestic water heating for adjacent residential building
Leaders in district heating include European companies like Tranter and SRB Energy; notable US projects is Co-Op City in NY

Transmission Technology Roadmap

BPA Transmission Technology Roadmap

- The Transmission Technology Roadmap specifically addresses challenges facing BPA's high voltage transmission system and its interactions with generation sources and the distribution systems of its customers. The challenges are grouped in the following major areas:
  - A. Transmission Planning Operational Challenges
    - Power System Modeling
    - Transmission Operations
    - Power Grid Optimization
    - Transmission Scheduling
    - Workforce Enhancement
  - B. New Technology Integration Challenges
    - Changing Generation Resources
    - Changing Load Characteristics
    - Assets Management & Innovation

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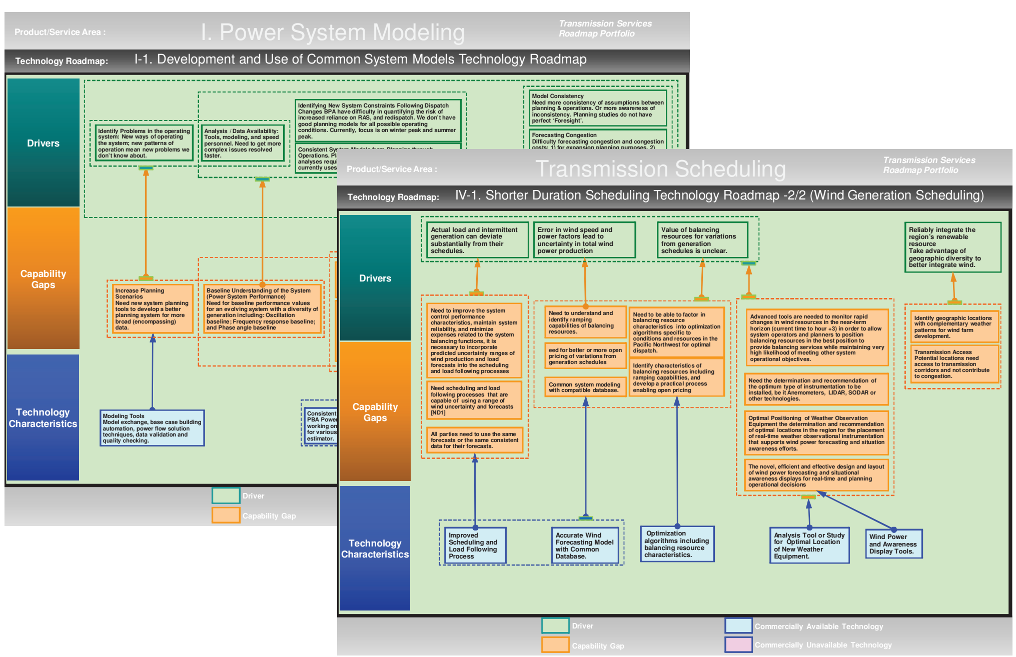
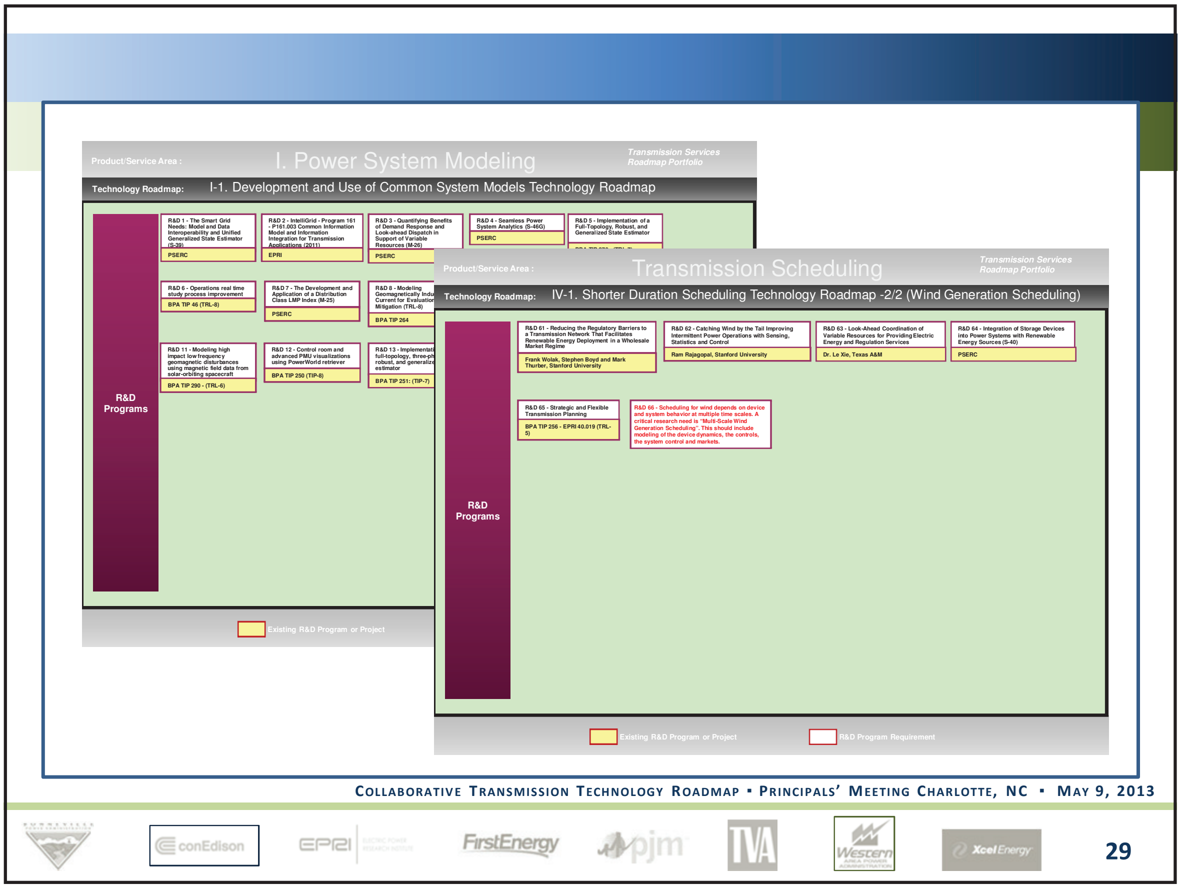
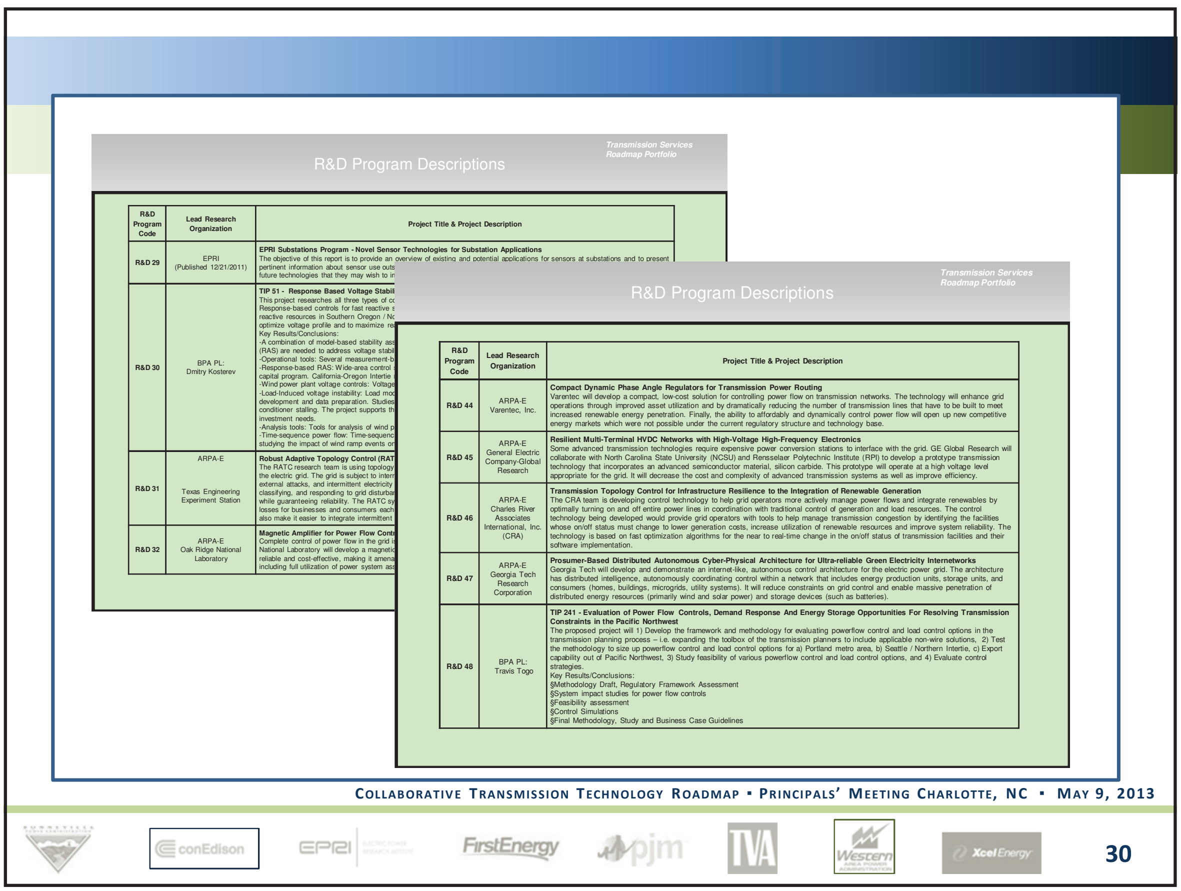

Product/Service Area :
I. Power System Modeling
Transmission Services Roadmap Portfolio
Technology Roadmap:
I-1. Development and Use of Common System Models Technology Roadmap
Drivers
Capability Gaps
Technology Characteristics
Driver
Capability Gap
Product/Service Area :
Transmission Scheduling
Transmission Services Roadmap Portfolio
Technology Roadmap:
IV-1. Shorter Duration Scheduling Technology Roadmap -2/2 (Wind Generation Scheduling)
Drivers
Capability Gaps
Technology Characteristics
Driver
Capability Gap
Commercially Available Technology
Commercially Unavailable Technology





R&D Program Code	Lead Research Organization	Project Title & Project Description
R&D 44	ARPA-E Varentec, Inc.	**Compact Dynamic Phase Angle Regulators for Transmission Power Routing** Varentec will develop a compact, low-cost solution for controlling power flow on transmission networks. The technology will enhance grid operations through improved asset utilization and by dramatically reducing the number of transmission lines that have to be built to meet increased renewable energy penetration. Finally, the ability to affordably and dynamically control power flow will open up new competitive energy markets which were not possible under the current regulatory structure and technology base.
R&D 45	ARPA-E General Electric Company-Global Research	**Resilient Multi-Terminal HVDC Networks with High-Voltage High-Frequency Electronics** Some advanced transmission technologies require expensive power conversion stations to interface with the grid. GE Global Research will collaborate with North Carolina State University (NCSU) and Rensselaer Polytechnic Institute (RPI) to develop a prototype transmission technology that incorporates an advanced semiconductor material, silicon carbide. This prototype will operate at a high voltage level appropriate for the grid. It will decrease the cost and complexity of advanced transmission systems as well as improve efficiency.
R&D 46	ARPA-E Charles River Associates International, Inc. (CRA)	**Transmission Topology Control for Infrastructure Resilience to the Integration of Renewable Generation** The CRA team is developing control technology to help grid operators more actively manage power flows and integrate renewables by optimally turning on and off entire power lines in coordination with traditional control of generation and load resources. The control technology being developed would provide grid operators with tools to help manage transmission congestion by identifying the facilities whose on/off status must change to lower generation costs, increase utilization of renewable resources and improve system reliability. The technology is based on fast optimization algorithms for the near to real-time change in the on/off status of transmission facilities and their software implementation.
R&D 47	ARPA-E Georgia Tech Research Corporation	**Prosumer-Based Distributed Autonomous Cyber-Physical Architecture for Ultra-reliable Green Electricity Internetworks** Georgia Tech will develop and demonstrate an internet-like, autonomous control architecture for the electric power grid. The architecture has distributed intelligence, autonomously coordinating control within a network that includes energy production units, storage units, and consumers (homes, buildings, microgrids, utility systems). It will reduce constraints on grid control and enable massive penetration of distributed energy resources (primarily wind and solar power) and storage devices (such as batteries).
R&D 48	BPA PL: Travis Togo	**TIP 241 - Evaluation of Power Flow Controls, Demand Response And Energy Storage Opportunities For Resolving Transmission Constraints in the Pacific Northwest** The proposed project will 1) Develop the framework and methodology for evaluating powerflow control and load control options in the transmission planning process – i.e. expanding the toolbox of the transmission planners to include applicable non-wire solutions, 2) Test the methodology to size up powerflow control and load control options for a) Portland metro area, b) Seattle / Northern Intertie, c) Export capability out of Pacific Northwest, 3) Study feasibility of various powerflow control and load control options, and 4) Evaluate control strategies. Key Results/Conclusions: §Methodology Draft, Regulatory Framework Assessment §System impact studies for power flow controls §Feasibility assessment §Control Simulations §Final Methodology, Study and Business Case Guidelines

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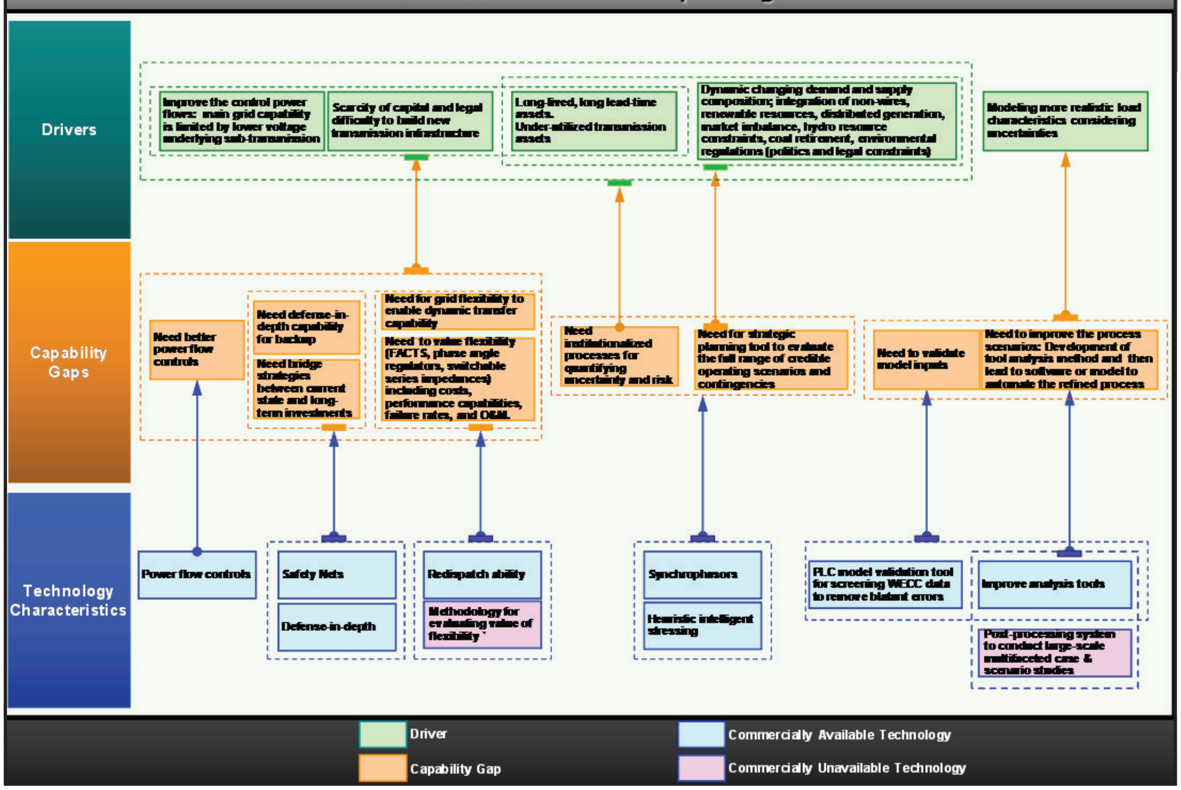
Specific Content Example

Product/Service Area: **Transmission Planning and Operational Challenges**

Transmission Services Roadmap Portfolio

Technology Roadmap: **Risk based transmission planning**



Product/Service Area :

Transmission Services Roadmap Portfolio

Technology Roadmap:

R&D Programs

R&D 3 - TCRM: Transmission Curtailment Risk Measure	BPA, ColumbiaGrid
R&D 5 - Multi-period planning models under uncertainty	James D. McCalley Harpole, Iowa State University
R&D 6 - Two-Stage transmission Mixed Integer LP under Uncertainties	Johns Hopkins University, JHU E2SHI
R&D 9 -Synchro-Phasors - Better visibility with high resolution data	BPA
R&D 13 - Post-mortem Analysis (including compliance monitoring)	

Existing R&D Program or Project

R&D Program Requirement

PROJECT TASKS, SCHEDULE, & DELIVERABLES

May 9	Late June	Late Aug.	Nov. 15
Principals' Meeting, Charlotte, NC	Workshop 1, Portland, OR	Workshop 2, TBD	**Publish Transmission Technology Roadmap**

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

- Executives
- Senior leadership
- Senior-level operational managers

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

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Workshop 1

Objective: Identify strategic Drivers and Capability Gaps for the high-priority Technology Areas selected at the Principals' meeting of May 9, 2013.

Tentative Schedule: Two-day workshop at BPA Headquarters in Portland, Oregon, tentatively planned for the week of June 24–28, 2013.

Participants Sought from Collaborating Organizations: 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 transmission technologies to achieve the corporate strategy. These experts will provide input on the "strategic" levels of the roadmap critical in developing a resource that directly supports key business objectives.

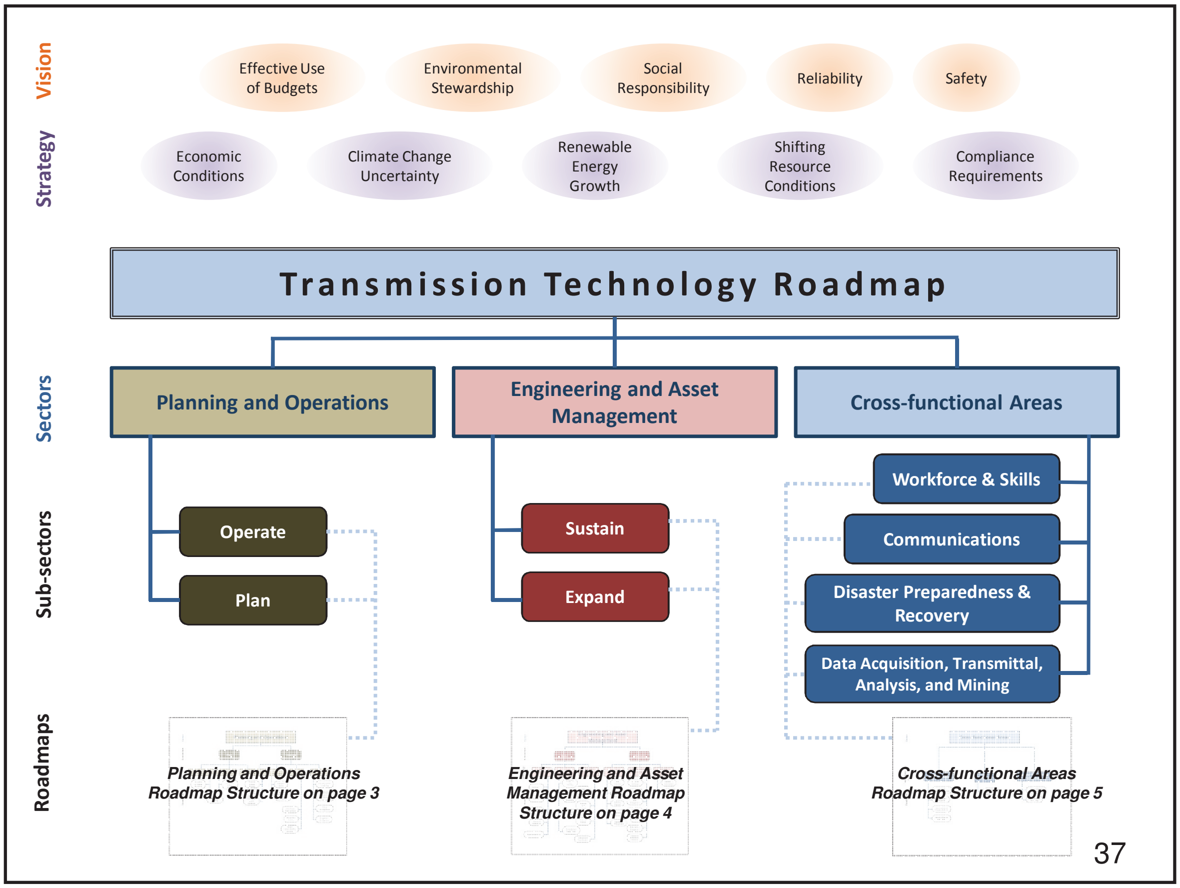
PROJECT TASKS, SCHEDULE, & DELIVERABLES

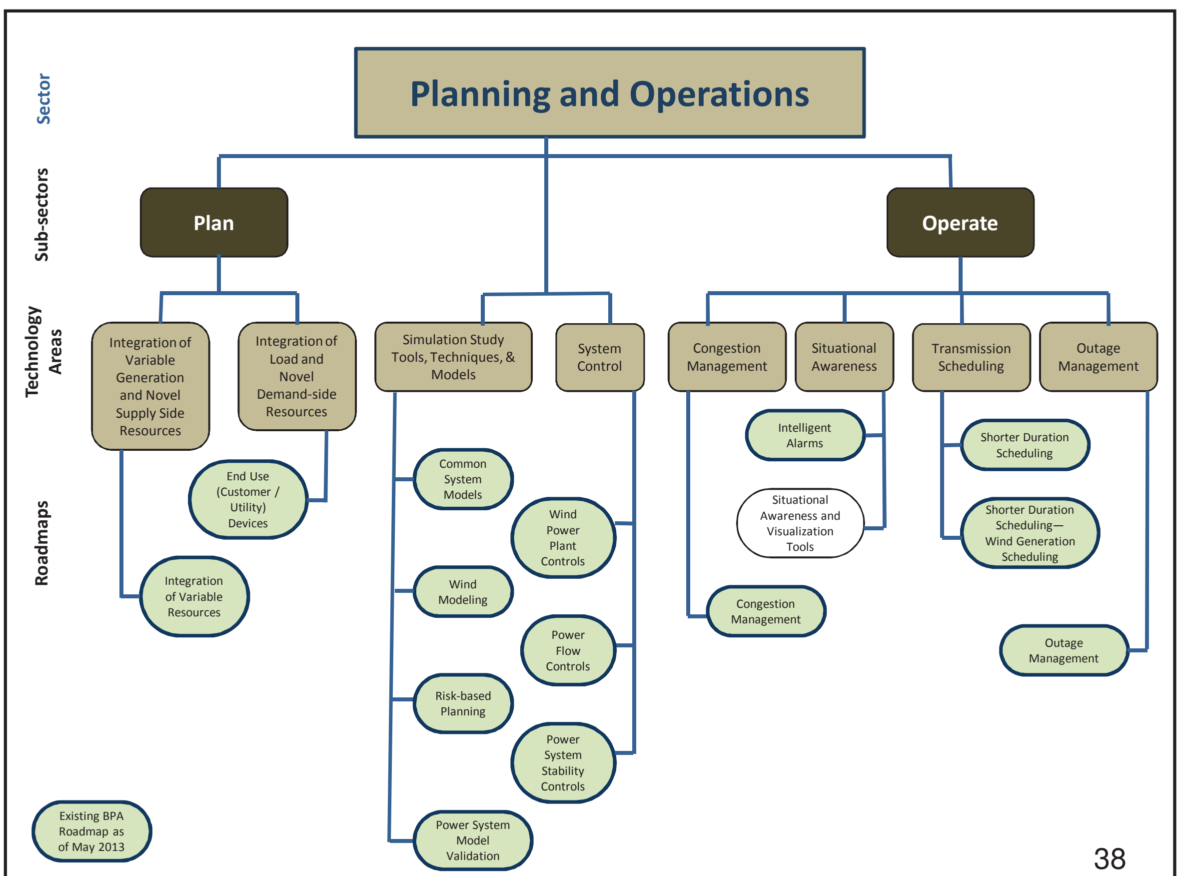
Workshop 2

Objective: Within the Technology Areas selected at the Principals' Meeting, identify the Technology Characteristics and R&D Programs that address strategic Drivers and Capability Gaps identified during Workshop 1.

Tentative Schedule: 1-day workshop, tentatively planned for August 2013, at a location yet to be decided.

Participants Sought from Collaborating Organizations, National Laboratories, Universities, R&D Organizations, and Vendors: Subject matter experts (SMEs) from throughout North America to develop the "tactical" content of the roadmaps—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 transmission technologies, models, algorithms, systems, etc.





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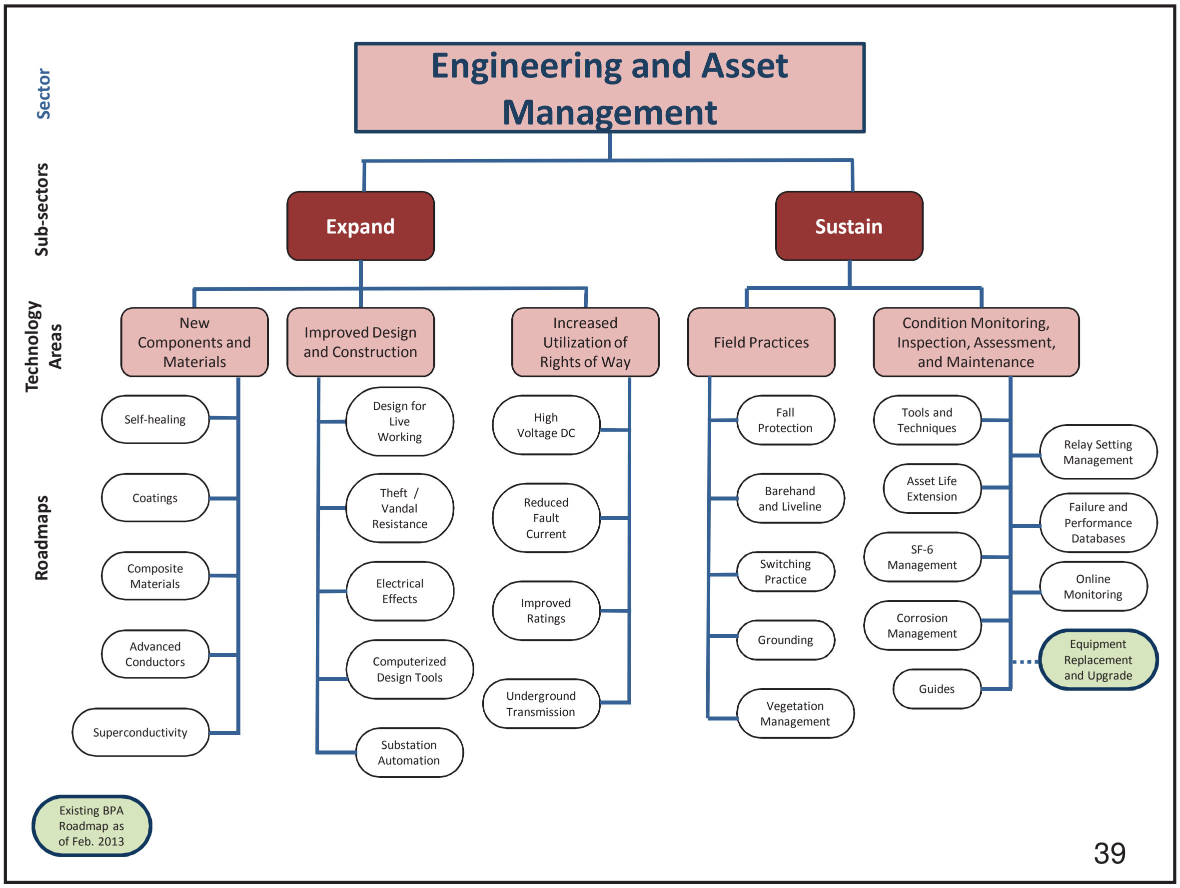
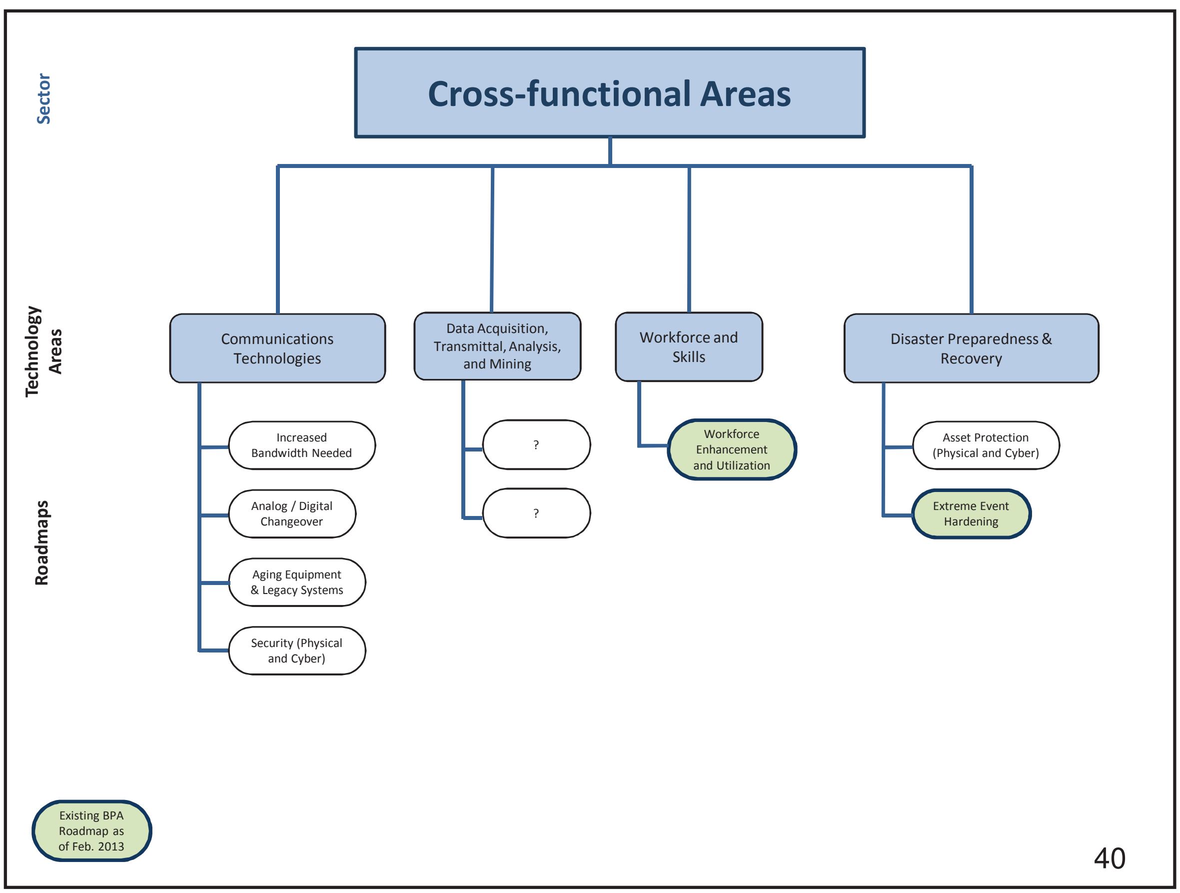
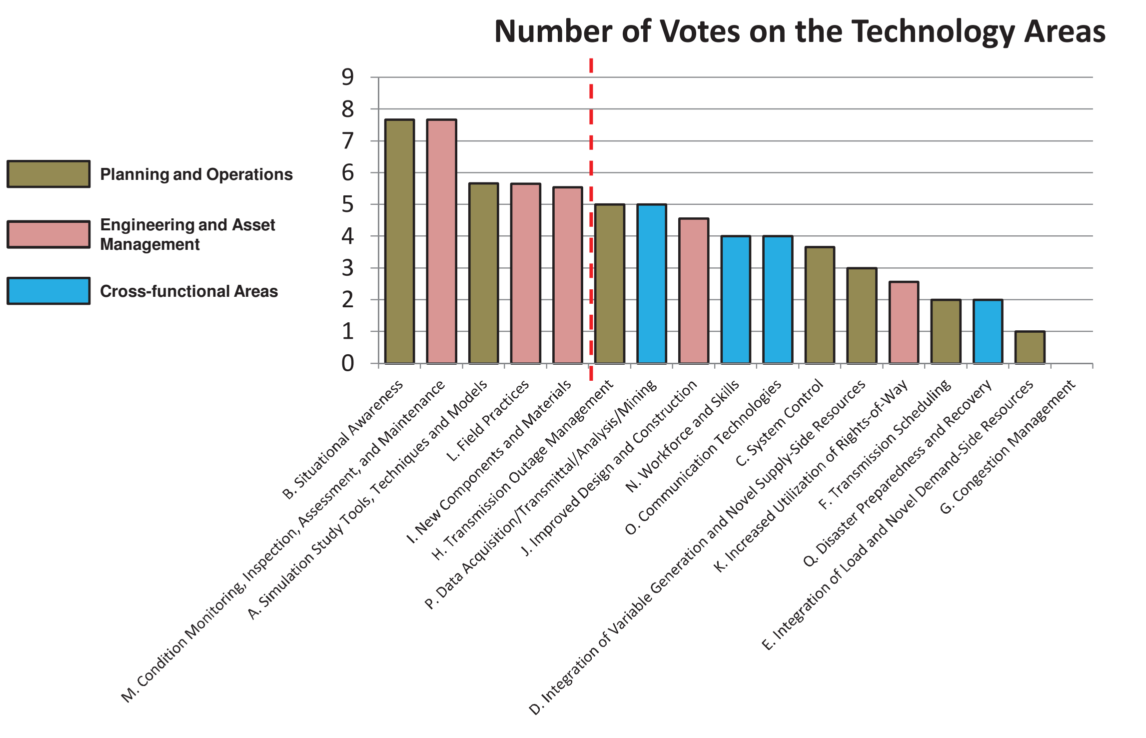

Sector
Sub-sectors
Technology Areas
Roadmaps
Engineering and Asset Management
Expand
Sustain
New Components and Materials
Improved Design and Construction
Increased Utilization of Rights of Way
Field Practices
Condition Monitoring, Inspection, Assessment, and Maintenance
Self-healing
Coatings
Composite Materials
Advanced Conductors
Superconductivity
Design for Live Working
Theft / Vandal Resistance
Electrical Effects
Computerized Design Tools
Substation Automation
High Voltage DC
Reduced Fault Current
Improved Ratings
Underground Transmission
Fall Protection
Barehand and Liveline
Switching Practice
Grounding
Vegetation Management
Tools and Techniques
Asset Life Extension
SF-6 Management
Corrosion Management
Guides
Relay Setting Management
Failure and Performance Databases
Online Monitoring
Equipment Replacement and Upgrade
Existing BPA Roadmap as of Feb. 2013
39


Sector
Technology Areas
Roadmaps
Cross-functional Areas
Communications Technologies
Data Acquisition, Transmittal, Analysis, and Mining
Workforce and Skills
Disaster Preparedness & Recovery
Increased Bandwidth Needed
Analog / Digital Changeover
Aging Equipment & Legacy Systems
Security (Physical and Cyber)
?
?
Workforce Enhancement and Utilization
Asset Protection (Physical and Cyber)
Extreme Event Hardening
Existing BPA Roadmap as of Feb. 2013
40

REVIEW TECHNOLOGY AREAS AND PRE-WORK SURVEY



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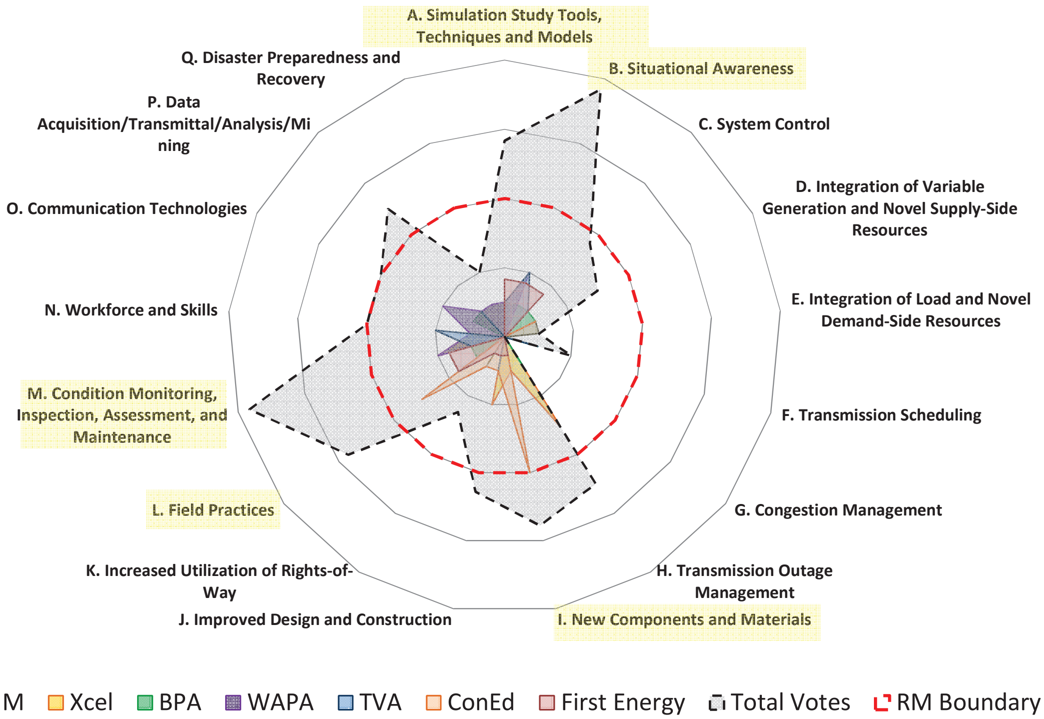

Discuss Corporate Priorities & Strategies

Xcel Energy

Service Territory:
•Assets in 10 states; operating in3 NERC Regions
•Net book value
$3.9 biillllion iin 2012
• 18,600 line miles, 1,100 substations
• 1,200 employees
• 2011 peak demand 22,000 MW

Strategic Plan

- **CUSTOMERS:** Our customers' quality of life depends on the energy we provide
- **PEOPLE:** Vitality comes from our people. Treat all people with respect.
- **FINANCIAL:** Continuously improve our business.
- **ASSETS:** Offering a comprehensive portfolio of energy-related products and services to 3.4 million electricity and 1.9 million natural gas customers
- **OPERATIONS:** "Building the Core" investing in our core businesses to provide safe, reliable energy to customers at a reasonable price

Priority Technology Areas

H. Transmission Outage Management:	3
I. New Components and Materials:	1
J. Improved Design and Construction:	2
M. Condition Monitoring, Inspection, Assessment, and Maintenance:	2
N. Workforce and Skills:	1
P. Data Acquisition / Transmittal / Analysis / Mining:	1

Western Area Power Administration

Service territory includes 15 central & western states. WAPA's 17k miles of transmission lines carries electricity from 56 power plants with a total capacity of 10,505 MW.

Strategic Plan

- **CUSTOMERS:** Provide reliable, cost-based power and transmission services to our customers.
- **PEOPLE:** Hire, develop and retain high performance employees.
- **FINANCIAL:** Maintain financial stability in the face of uncertain appropriations.
- **ASSETS:** Formalize an asset management program and enterprise risk management program.
- **OPERATIONS:** Maintain, improve, upgrade and expand the transmission system for the reliable delivery of energy.

Priority Technology Areas

A. Simulation Study Tools, Techniques and Models:	1
B. Situational Awareness:	2
M. Condition Monitoring, Inspection, Assessment, and Maintenance:	2
N. Workforce and Skills:	1
O. Communication Technologies:	2
P. Data Acquisition / Transmittal / Analysis / Mining:	1
Q. Disaster Preparedness and Recovery:	1

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Service territory includes most of Tennessee and parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina and Virginia, covering 80,000 square miles and providing electricity to more than 9 million people at prices below the national average. TVA sells electricity to 155 local power companies and 57 directly served industries and federal facilities.

Strategic Plan

- **CUSTOMERS**: Maintain power reliability, provide competitive rates, and build trust with TVA's customers
- **PEOPLE**: Build pride in TVA's performance and reputation
- **FINANCIAL**: Adhere to a set of sound financial guiding principles to improve TVA's fiscal performance
- **ASSETS**: Use TVA's assets to meet market demand and deliver public value
- **OPERATIONS**: Improve performance to be recognized as an industry leader

Priority Technology Areas

A. Simulation Study Tools, Techniques and Models:	1
B. Situational Awareness:	2
C. System Control:	1
F. Transmission Scheduling:	1
J. Improved Design and Construction:	1
M. Condition Monitoring, Inspection, Assessment, and Maintenance:	1
N. Workforce and Skills:	2
P. Data Acquisition / Transmittal / Analysis / Mining:	1

Service Territory: Serving a population of about 60 million over 214,000 square miles, and a peak demand of 163,848 MW. Service territory includes all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

Strategic Plan

- **CUSTOMERS:** Understand customer needs and deliver valued service to meet those needs in a cost-efficient manner
- **PEOPLE:** Achieve productivity through the efficient union of superior knowledge workers
- **FINANCIAL:** Continuing as the lowest-cost Regional Transmission Organization
- **ASSETS:** Maintain 59,750 miles of high-voltage transmission lines
- **OPERATIONS:** Regional Transmission Expansion Plan (RTEP) identifies transmission system additions and improvements needed

Priority Technology Areas

A. Simulation Study Tools, Techniques and Models:	1
B. Situational Awareness:	1
D. Integration of Variable Generation and Novel Supply-Side Resources:	1
E. Integration of Load and Novel Demand-Side Resources:	1
H. Transmission Outage Management:	1
K. Increased Utilization of Rights-of-Way:	1
O. Communication Technologies:	1
P. Data Acquisition / Transmittal / Analysis / Mining:	1
Q. Disaster Preparedness and Recovery:	1
Other: Storage: compressed air, battery, water heaters, etc.	1

FirstEnergy

Service territory covers seven states and stretches from the Ohio-Indiana border to the New Jersey shore, the companies operate a vast infrastructure over 65,000 square miles with more than 194,000 miles of distribution lines serving its 6 million customers.

Strategic Plan

- **CUSTOMERS:** Provide reliable, cost-based power and transmission services
- **PEOPLE:** Provide our employees with opportunities to sharpen their skills, embrace new challenges and advance their professional and personal growth
- **FINANCIAL:** By achieving strong performance in three core businesses deliver greater financial stability
- **ASSETS:** Build diverse assets as key advantages in the energy business
- **OPERATIONS:** Pursuing cost-effective measures to enhance the reliability and efficiency of our regulate utility operations – including strategic investments

Priority Technology Areas

A. Simulation Study Tools, Techniques and Models:	1.67
B. Situational Awareness:	1.67
C. System Control:	1.66
I. New Components and Materials:	0.55
J. Improved Design and Construction:	0.56
K. Increased Utilization of Rights-of-Way:	0.56
L. Field Practices:	1.66
M. Condition Monitoring, Inspection, Assessment, and Maintenance:	1.67

conEdison

Service Territory

Customers: 3,200,000

Population: 9,100,000

Area: 604 mi^2

Peak Demand: 13,141 MW

Con Ed Load Density: 21.8 MW/mi^2

Strategic Plan

- **CUSTOMERS:** Improve customer experience and deliver a consistent, high quality customer experience
- **PEOPLE:** Develop a customer-centric culture to foster trust and confidence among customers
- **FINANCIAL:** Standardization of business processes, coupled with enhanced cost management practices
- **ASSETS:** Using assets more efficiently to meet demand
- **OPERATIONS:** Develop long-range electric, gas, and steam demand forecasts

Priority Technology Areas

D. Integration of Variable Generation and Novel Supply-Side Resources:	1
I. New Components and Materials:	4
J. Improved Design and Construction:	1
K. Increased Utilization of Rights-of-Way:	1
L. Field Practices:	3
Q. Disaster Preparedness and Recovery:	1

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Service territory includes 8 western states over and 15k miles of transmission lines carrying a total capacity of 18,139 MW.

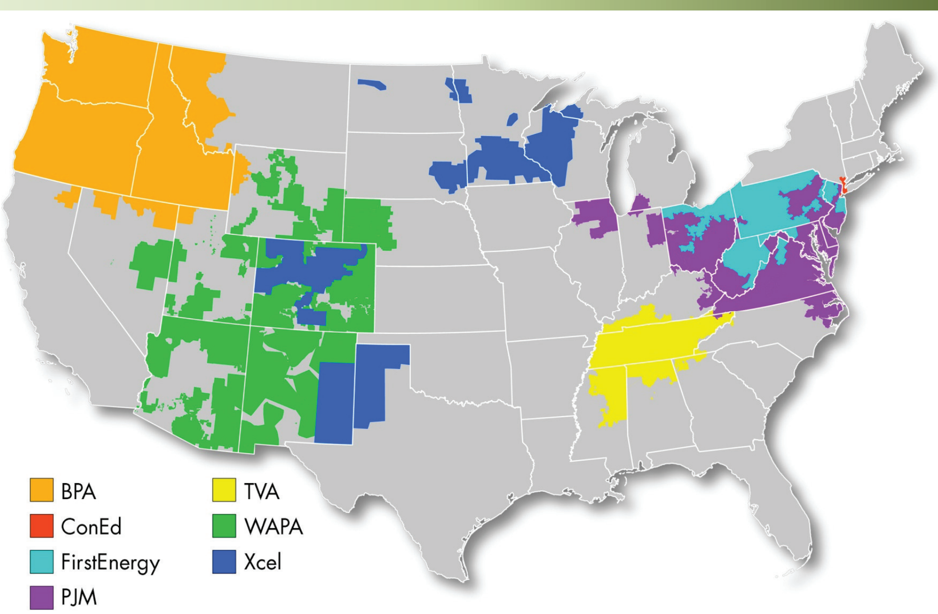
Strategic Plan

- **CUSTOMERS:** Deliver high reliability and low rates consistent with sound business principles;
- **PEOPLE:** Increase operational excellence & employee engagement
- **FINANCIAL:** Recover all of its costs, and repays the U.S. Treasury in full with interest for any money we borrow
- **ASSETS:** Preserve and enhance federal generation & transmission assets
- **OPERATIONS:** Transmission system that is adequate to the task of integrating and transmitting power from federal and nonfederal generating units

Priority Technology Areas

A. Simulation Study Tools, Techniques and Models:	1
B. Situational Awareness:	1
C. System Control:	1
D. Integration of Variable Generation and Novel Supply-Side Resources:	1
F. Transmission Scheduling:	1
H. Transmission Outage Management:	1
L. Field Practices:	1
M. Condition Monitoring, Inspection, Assessment, and Maintenance:	1
O. Communication Technologies:	1
P. Data Acquisition / Transmittal / Analysis / Mining:	1

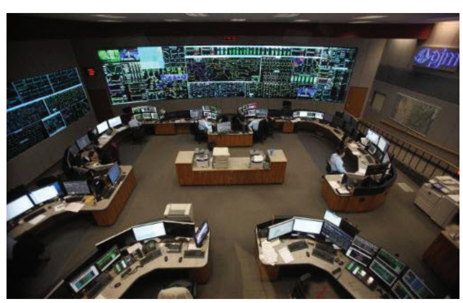
SERVICE TERRITORIES



IDENTIFY DRIVERS

IDENTIFY DRIVERS

Situational Awareness:
Power system visualization and situational awareness tools help transmission operators to understand the present conditions within and around the power system of interest and to anticipate the system conditions throughout the day. Examples of technology needs include grid monitoring and sensors such as phasor measurement units, decision support and visualization, intelligent alarms, real time assessment of power system stability, etc.



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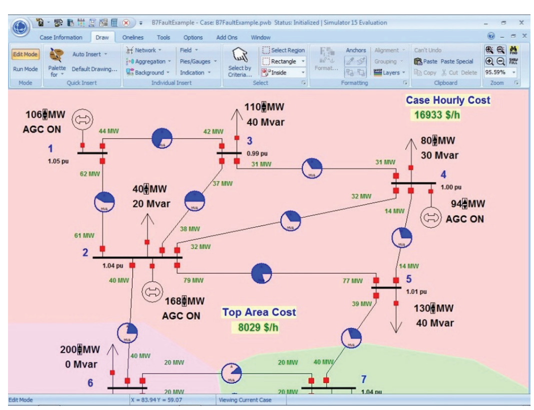
IDENTIFY DRIVERS

Condition Monitoring, Inspection, Assessment, and Maintenance:
Aging infrastructure is a challenge for utilities as new tools and methods are sought for equipment condition monitoring and periodic inspection. Information allowing assessment of equipment health is essential for asset management and equipment life cycle management, including life extension, replacement, and maintenance. Examples of technology challenges include advanced sensors, associated analytics to develop equipment condition information, and decision support tools for life cycle management.

IDENTIFY DRIVERS

Simulation Study Tools, Techniques and Models:
Simulation tools, techniques and models are used to perform studies such as power flow, stability, short-circuit, voltage stability, real-time contingency analysis, protection control setting, electromagnetic transients, etc. Examples of technology needs include development of models for novel equipment, model validation, integrated planning/ operations/engineering/design modeling data and tools, risk-based study tools and techniques, advanced computing techniques, etc.

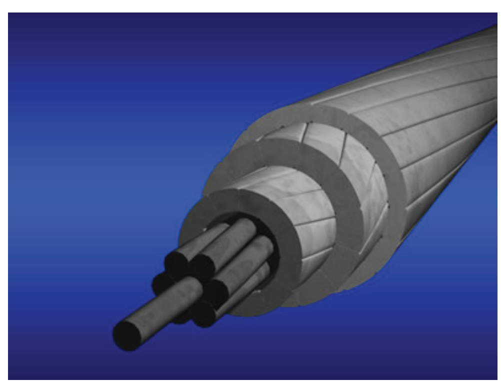


IDENTIFY DRIVERS

Field Practices:
New and enhanced field practices can improve worker safety and power system reliability while reducing capital and maintenance costs. Examples include switching safety and reliability, live maintenance practices, improved grounding procedures, vegetation management, etc.

IDENTIFY DRIVERS

New Components and Materials:
Development, evaluation, and implementation of a set of new and advanced components for existing and new transmission infrastructure can lower capital costs, improve reliability, improve life expectancy, enhance environment compatibility, increase power flow carrying capability, reduce O&M costs, etc. Examples of new components include high-temperature low-sag conductors, superconducting fault current limiters, nano-technology, etc.



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NEXT STEPS

- Road mapping team to send executive summary and minutes from this meeting
- Principals to identify people to send to Workshop 1, at the BPA Portland Office, tentatively planned for the week of June 24-28, 2013

  Senior level staff involved in developing or implementing corporate strategy (including public policy, regulatory compliance, business development, etc.), as well as having familiarity with the role played by transmission technologies to achieve the corporate strategy.

  A list of representatives from each utility is **due by May 24, 2013**.

NEXT STEPS

- Principals to identify people to send to Workshop 2, tentatively planned for late August or early September 2013, at a location yet to be decided

  Practitioners, subject matter experts (SMEs) and R&D community, specifically focused on the prioritized Technology Areas.

  A list of representatives from each utility is **due by May 24, 2013**.

- Review of action items

  To be added by Bob and Judith - day of meeting

Closing

Thank you for participating!

Contact Info:

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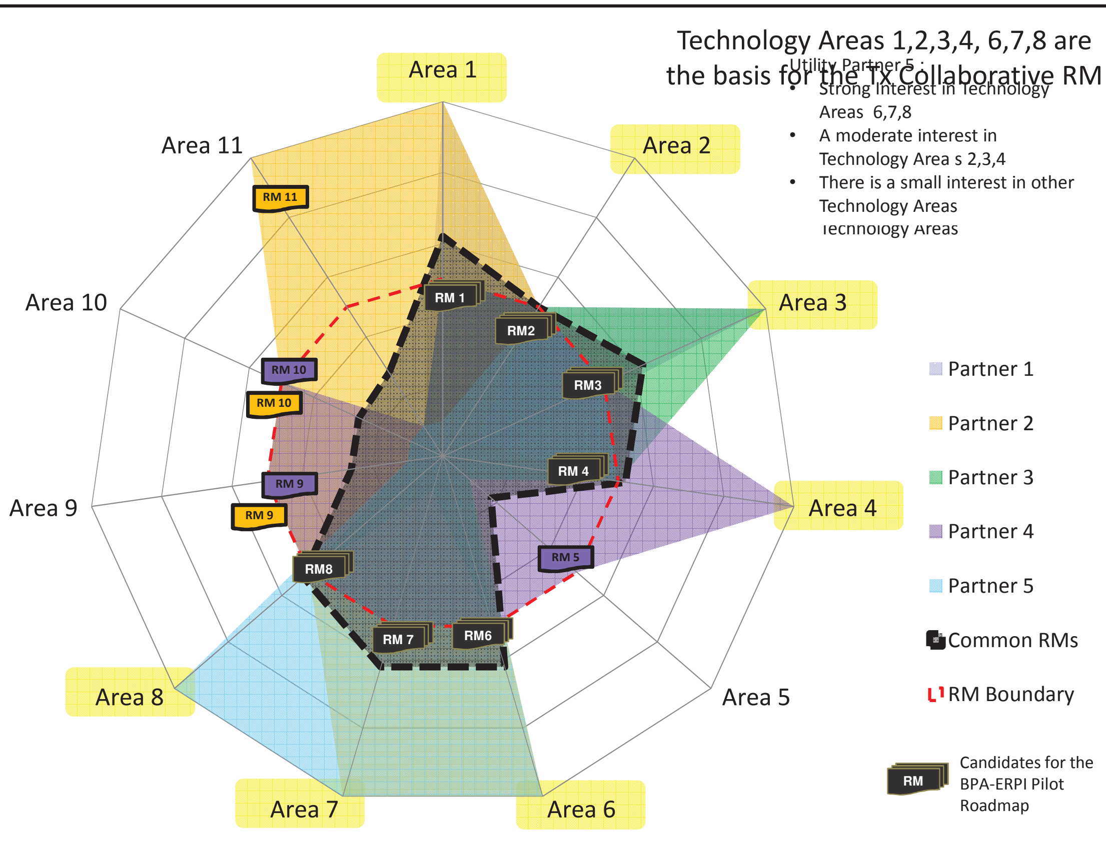
nbhatt@epri.com

Bob Entriken
(650) 855-2198
rentriken@epri.com



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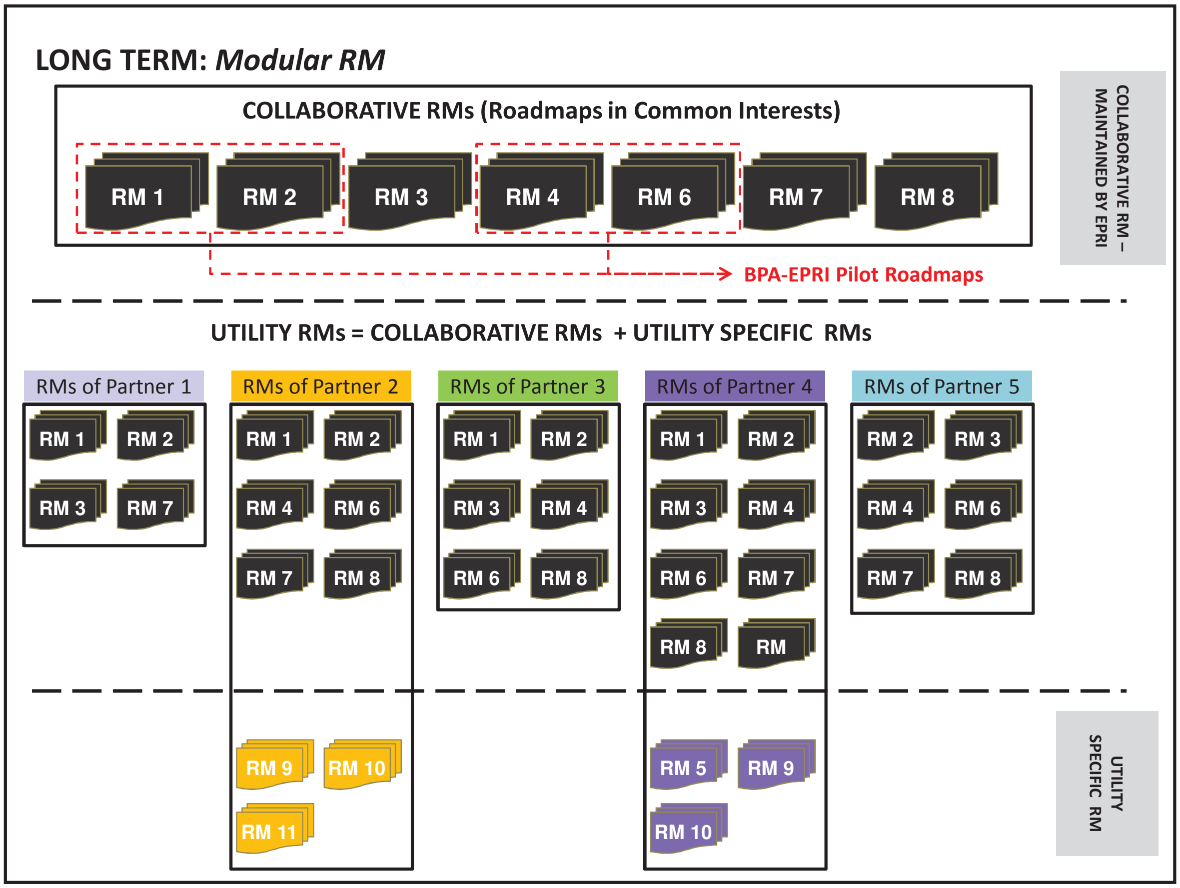

IDENTIFY DRIVERS

Transmission Outage Management:
Contemporary outage management practices do not yet optimize outage schedules for lower cost and increased reliability. An improved outage management system could schedule maintenance work, balance labor, and consolidate locations, in order to bring the benefits like reduced pressure to replace equipment 'Hot' (without an outage), increased flexibility to take outages on power system equipment and lines, and optimal use of planned outage windows.

IDENTIFY DRIVERS

Data Acquisition/Transmittal/Analysis/Mining:
As users demand more information, and communication networks collect and transmit large quantities of data, the challenge remains to convert the data into useful information for utility decision makers. This technology area involves primary collection points, data consolidation, further transmittal to databases, and the analysis of large quantities of data.

IDENTIFY DRIVERS

Workforce and Skills:
A modern power system workforce requires new skills, knowledge capture and training tools, and training databases. The workforce and skills area also includes human performance challenges to improve human safety and power system reliability. The driving forces for this area include workforce transformation, due to retirement of experienced industry staff, and emerging issues (such as NERC compliance) and technologies.

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IDENTIFY DRIVERS

Communication Technologies:
Utilities and ISO/RTOs rely on robust, reliable, and secure communication networks that can meet the diverse needs of all users across the entire interconnected transmission grid. New telemetry, such as synchrophasors, smart metering, and equipment condition monitoring sensors, place higher performance requirements on the network. Examples of issues to focus on include increased bandwidth requirements, replacement of legacy equipment, and secure communication.

Meeting Notes

Thursday, May 9, 2013

SUBJECT: **Collaborative Transmission Technology Roadmapping Principals' Meeting**

Attendees

Daniel Brooks, Mark McGranaghan, Andrew Phillips, Robert Entriken (EPRI), Terry Oliver, Judith Estep, Tugrul Daim, James Hillegas-Elting, Jim Bowen, Jeff Hildreth (BPA), Al Choi, Dave Cenedella (Xcel), Joe Waligorski (FE), Mahendra Patel, Sarah Burlew (PJM), Hugh Grant, Mike Simione (ConEd), Greg Henrich, DeJim Lowe, Sarada Madugula (TVA), Subhash Paluru (WAPA)

Action Items

- [EPRI] Send meeting summary, presentation slides and electronic files of handouts to Principals and POCs.
- [Attendees] Provide contact information for Workshops 1 and 2 participants by 24 May.

Meeting Outcome: The following Technology Areas were chosen as the focus for the pilot transmission technology roadmap:

A. Simulation Tools: 5 (Votes)
B. Situation Awareness: 5
M. Condition Monitoring: 7
L. Field Practices: 3
P. Data Acquisition: 5

Next Meetings

- Workshop 1 is on June 25-26 in Portland.
- Workshop 2 is on September 19 in Charlotte.

Utility/RTO Presentations

Xcel Issues: FERC Order 1000, building transmission in large sections, renew substations consistently, retirements, O&M budget restrictions

TVA Issues: Operational flexibility across alternative future generation mixes, extend asset life, add monitoring and assessment, O&M cost reductions, "compliance planning," need to solve stochastic power flows, scheduling ramping events, substation interface standards, workforce training, data processing

PJM Issues: substation interface standards, simulate asset health, optimize for uncertainty, deriving appropriate statistics, neighboring events, integrate DR, restoration

FirstEnergy Issues: seamless software operation between devices and tools, simple and clear decision support in operations, protection systems flexible to changing network configurations, safety management in the field, monitoring according to "importance," multi-skill training.

Consolidated Edison Issues: high reliability for critical loads, maintain the system in place, moving to probabilistic methods, using efficiency to control loads, increased fault currents from distributed generation, becoming proactive about asset health, communicating value of preparing for HILF events, probabilistic planning.

BPA Issues: variable generation is requiring more nimble and flexible operations, aging staff and assets, keeping practice up to date with technical developments, wind ramps and events, O&M cost constraints, archiving event data,

WAPA Issues: changing business model for independent financing, initiating new research function, consistent practices and techniques, retirements, scarce water, secure communications

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Technology Areas w/Drivers
A (Simulation Study Tools, Techniques and Models)
Accuracy
Computing capability
Fast-moving technologies and dynamic systems--how do the models keep up?
Inability to forecast dynamic systems accurately
Increased number of contingencies
Increasing volume and quality of data
Limited capital
Long-lived assets
Need for real-time modeling
Need for shorter turn-around times for modeling
Post-processing--limits and possibilities
Push to drive the grid to its limits; tighter margins drive need for accuracy and trust
Regulations
Risks
Ubiquity of power electronics
B (Situational Awareness)
Application of field data to decision-making and schedules
Asset condition
Connecting distributed generation resources and renewables
Increased flows across larger areas
Increased reliability
Increasingly dynamic nature of the grid
Markets
Need to understand behavior and operations of distributed and intermittent resources
Operations at the margins
Prevention
Reluctance to build new lines
Safety
System status
L (Field Practices)
Safety
Aging workforce leads to the need for: knowledge transfer; changing field practices (aging workers can't always do the physical work that younger people can do); and culture change
Outage scheduling
Reduced operations and maintenance budgets
Increased reliability
Push for significant productivity gains
Balancing need for long-term equipment reliability with decreasing or static maintenance budgets
Use of new communications and IT tools (phones, etc.); technology enablement
Productivity
Mobility of information, remote communications, data transmission, etc.

Technology enablement through culture change and application of new communications and data management tools
M (Condition Monitoring, Inspection, Assessment, and Maintenance)
Aging assets--need to enable an asset management strategy to prioritize replacement
Application of quantitative / scientific data and statistics to justify asset investments
Budget constraints (focus on short-term budgets and five-year payback)
Condition-based maintenance
Increase productivity (i.e., reduce the need for staff to do on-site inspections)
Increase reliability
Increase safety
Predictive maintenance
Risk management to enable cost management
P (Data Acquisition/Transmittal/Analysis/Mining)
Articulate research goals linked directly to data so as to characterize in terms of ROI
Foundational to other technology areas
Much more data available
Need to access archived data efficiently and effectively
Need to archive increasing amounts of data
Standardized approach to throughput, streaming analysis, etc.

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Section 3

Workshop 1: Drivers and Capability Gaps, June 25–26, 2013

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Collaborative Transmission Technology Roadmap

Pilot Project

Workshop 1: Drivers & Capability Gaps

June 25–26, 2013

Executive Meeting Center, DoubleTree Hotel

Portland, OR

Objectives

1) **Day 1:** Develop consensus on teams and approach
2) **Day 1:** Review, revise, and identify Drivers and Capability Gaps
3) **Day 2:** Team presentations: Summary insights and conclusions
4) **Day 2:** Synthesize team requirements in the Data Acquisition / Management area

Agenda – Day 1

8:00 a.m.	**Welcome, logistics, & introductions** **Overview of workshop objectives** **Overview of roadmapping process**	Terry Oliver, BPA Daniel Brooks, EPRI Jeff Hildreth, BPA Tugrul Daim, PSU James Hillegas-Elting, BPA
Objective 1	**Develop consensus on teams and approach**	
9:30 a.m.	**Review draft roadmap structure** **Determine teams & establish strategic approach**	Jeff Hildreth, BPA
10:00 a.m.	***BREAK***	
Objective 2	**Review, revise, and 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; the environment; market conditions and projections; consumer behavior and preferences; and organizational goals and culture. **Identify Capability Gaps linked to Drivers** **Focus Question:** What are the barriers or shortcomings that stand in the way of meeting Drivers?	Workshop Participants
12:30 p.m.	***WORKING LUNCH***	
1:00 p.m.	**Continue working on Objective 2**	Workshop Participants
3:30 p.m.	**Wrap-up & next steps**	Jeff Hildreth, BPA
4:00 p.m.	**Adjourn**	

Participants: *Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy ▪ PJM Interconnection ▪ Tennessee Valley Authority ▪ Western Area Power Administration ▪ Xcel Energy*

FINAL (June 25, 2013)

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COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP

PILOT PROJECT

June 25–26, 2013
DoubleTree Hotel
Portland, OR

WORKSHOP 1: DRIVERS & CAPABILITY GAPS

Objectives

1) **Day 1:** Develop consensus on teams and approach
2) **Day 1:** Review, revise, and identify Drivers and Capability Gaps
3) **Day 2:** Team presentations: Summary insights and conclusions
4) **Day 2:** Synthesize team requirements in the Data Acquisition / Management area

Agenda – Day 2

8:00 a.m.	**Welcome** **Check-in** **Prepare for team presentations**	Larry Bekkedahl, BPA Jeff Hildreth, BPA James Hillegas-Elting, BPA
Objective 3	**Team presentations: Summary insights and conclusions**	
8:30 a.m.	**Team presentations & group discussion (cross fertilization)**	Workshop Participants
10:30 a.m.	***BREAK***	
Objective 4	**Synthesize team requirements in the Data Acquisition / Management area**	
10:45 a.m.	**Summary analysis of workshop output in the Data Acquisition / Management Technology Area**	Navin Bhatt, EPRI Patricia Brown, EPRI
	Focus Question: Which elements in this Technology Area shall remain integrated into the other four Technology Areas and which shall be organized into a distinct Technology Area?	Workshop Participants
11:30 a.m.	***WORKING LUNCH***	
	Next steps **Workshop 2 participant ideas** **Conclusion**	Jeff Hildreth, BPA
12:00 p.m.	**Adjourn**	

COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP

PILOT PROJECT

June 25–26, 2013
DoubleTree Hotel
Portland, OR

WORKSHOP 1: DRIVERS & CAPABILITY GAPS

Objectives

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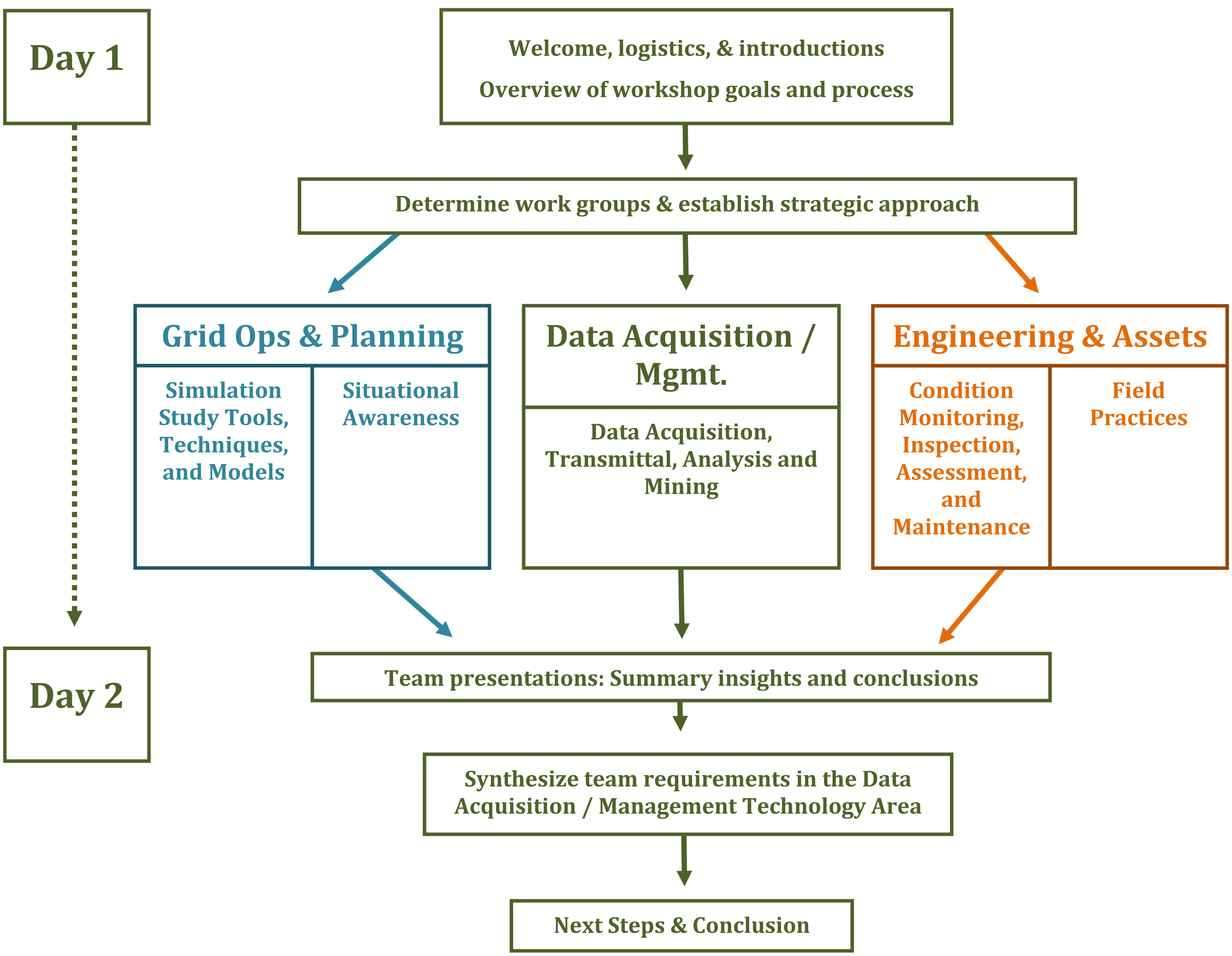
4) **Day 2:** Synthesize team requirements in the Data Acquisition / Management area

Agenda – Schematic



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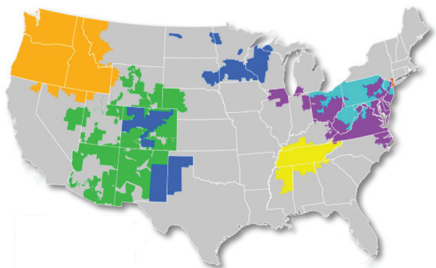
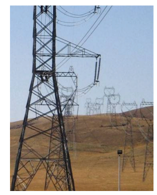
Collaborative Transmission Technology Roadmap

Workshop 1: Drivers & Capability Gaps

Portland, OR ▪ June 25–26, 2013

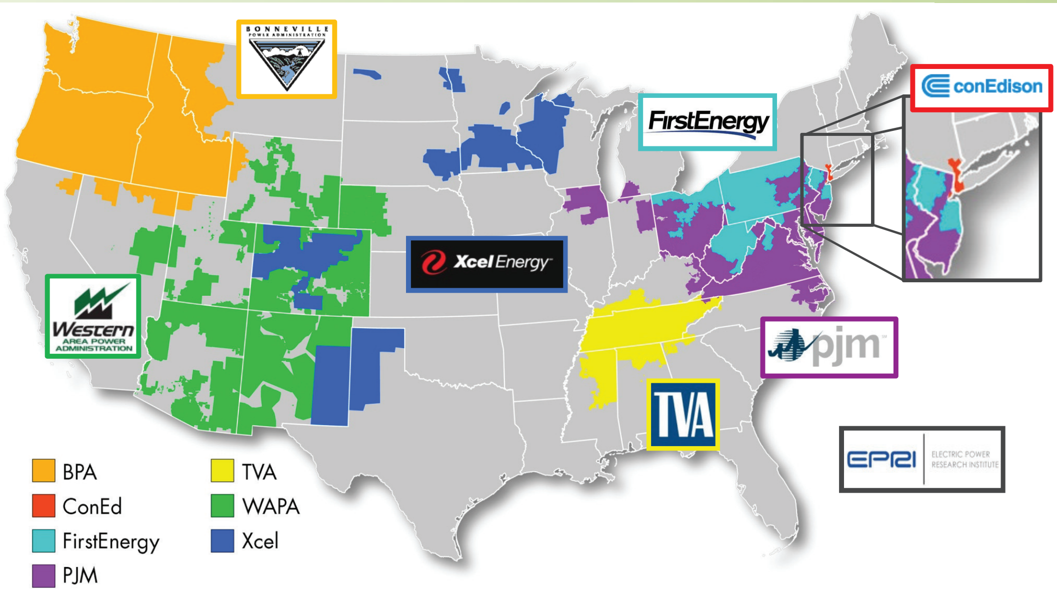




Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy ▪ PJM Interconnection ▪ Tennessee Valley authority ▪ Western Area Power Administration ▪ Xcel Energy

Service Territories



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OBJECTIVES

1) **Day 1:** Develop consensus on teams and approach
2) **Day 1:** Review, revise, and identify Drivers and Capability Gaps
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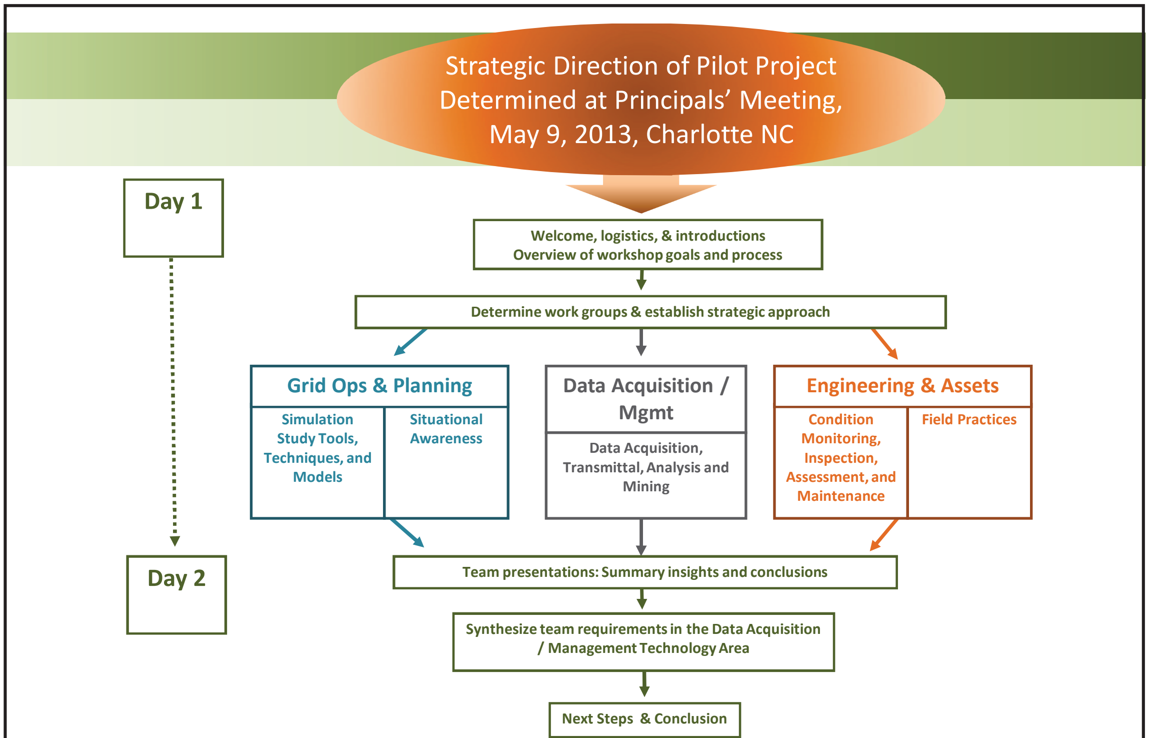
12:30 p.m.	*WORKING LUNCH*	
1:00 p.m.	Continue working on Objective 2	Workshop Participants
3:30 p.m.	Wrap-up & next steps	Jeff Hildreth, BPA
4:00 p.m.	Adjourn	

AGENDA—DAY 2

8:00 a.m.	**Welcome** **Check-in** **Prepare for team presentations**	Larry Bekkedahl, BPA Jeff Hildreth, BPA James Hillegas-Elting, BPA
Objective 3	**Team presentations: Summary insights and conclusions**	
8:30 a.m.	**Team presentations & group discussion (cross fertilization)**	Workshop Participants
10:30 a.m.	***BREAK***	
Objective 4	**Synthesize team requirements in the Data Acquisition / Management area**	
10:45 a.m.	**Summary analysis of workshop output in the Data Acquisition / Management Technology Area**	Navin Bhatt, EPRI Patricia Brown, EPRI
	Focus Question: Which elements in this Technology Area shall remain integrated into the other four Technology Areas and which shall be organized into a distinct Technology Area?	Workshop Participants
11:30 a.m.	***WORKING LUNCH***	
	Next steps **Workshop 2 participant ideas** **Conclusion**	Jeff Hildreth, BPA
12:00 p.m.	**Adjourn**	



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ROADMAPPING AT BPA & EPRI

TECHNOLOGY ROADMAPPING 101

Why technology roadmapping?

Visionary of Technology Roadmap

"A roadmap is an extended look at the future of a chosen field of inquiry composed from the collective knowledge and imagination of the brightest drivers of the change"

Robert Galvin

Former Motorola chairman and advocate of science and technology roadmaps

Values to Organization

- Linking strategy to product plans to technology plans
- Enabling corporate/national-level technology plans
- Focusing on longer-term planning
- Improving communication and ownership of plans
- Focusing on planning with priority setting

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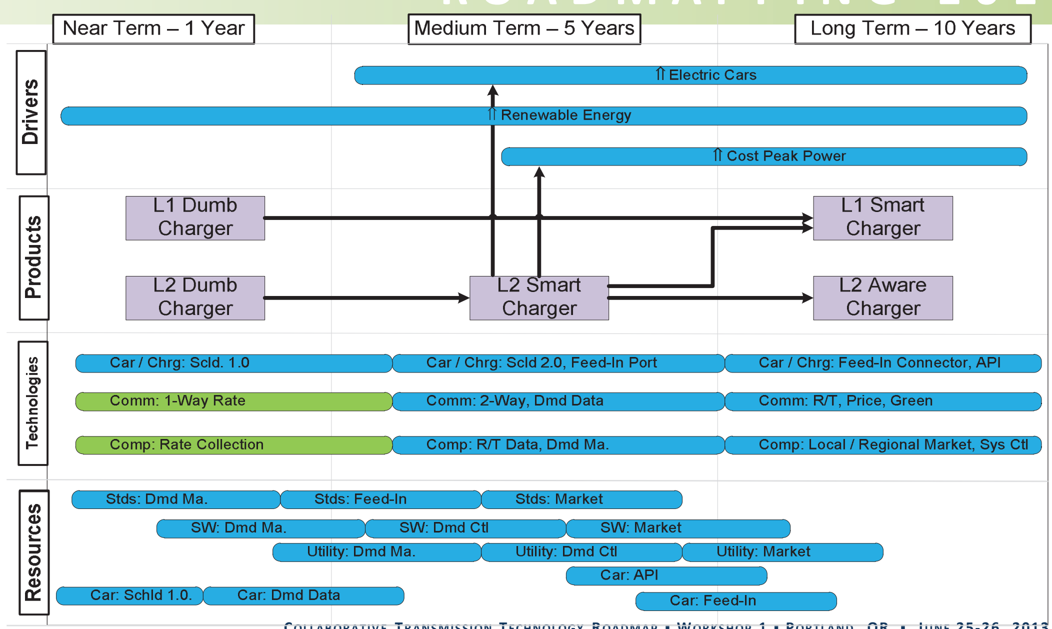
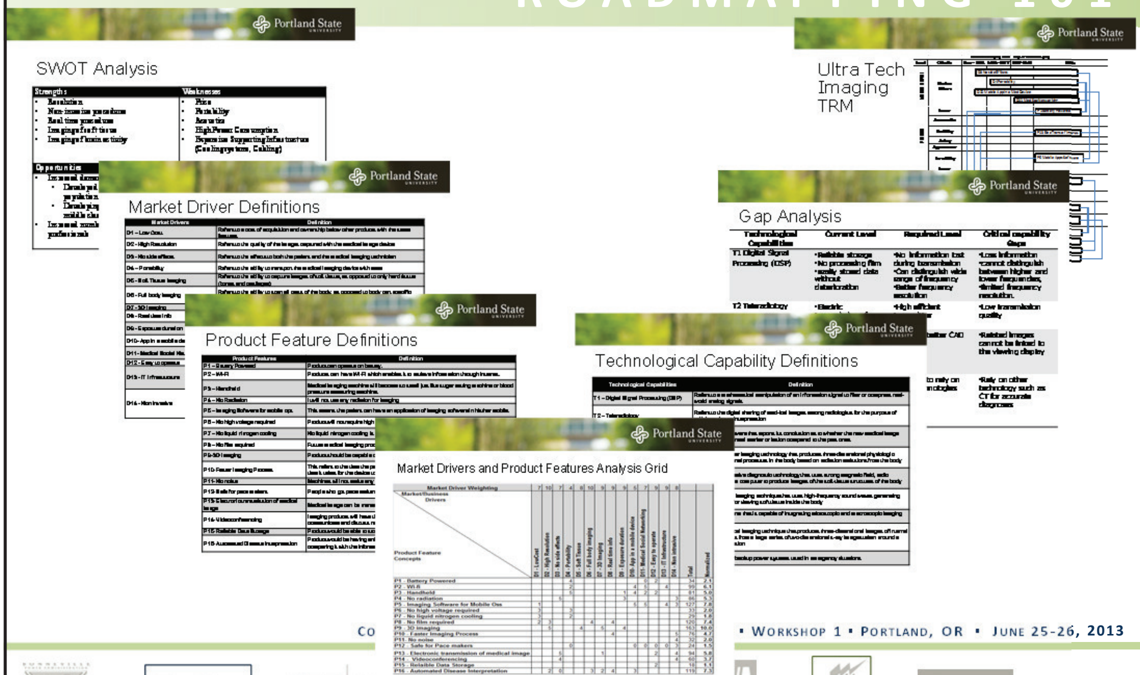
How do we roadmap technology?



TECHNOLOGY ROADMAPPING 101



TECHNOLOGY ROADMAPPING 101

An example from NW US

United Nations Framework Convention on Climate Change

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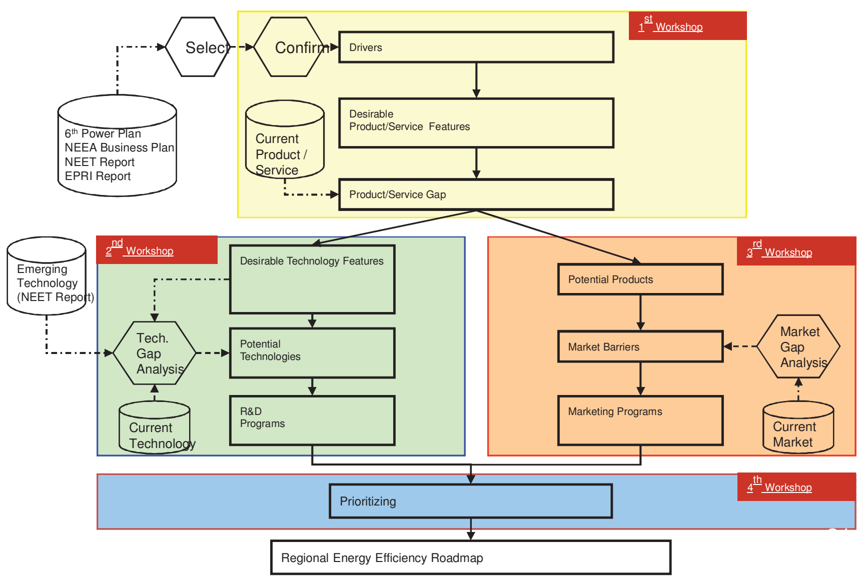
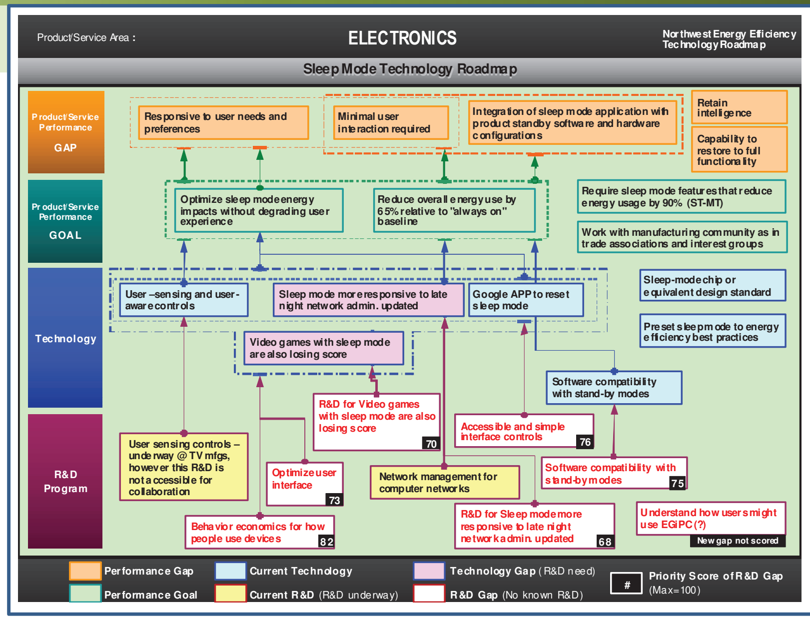
NW Regional Energy Efficiency Roadmap

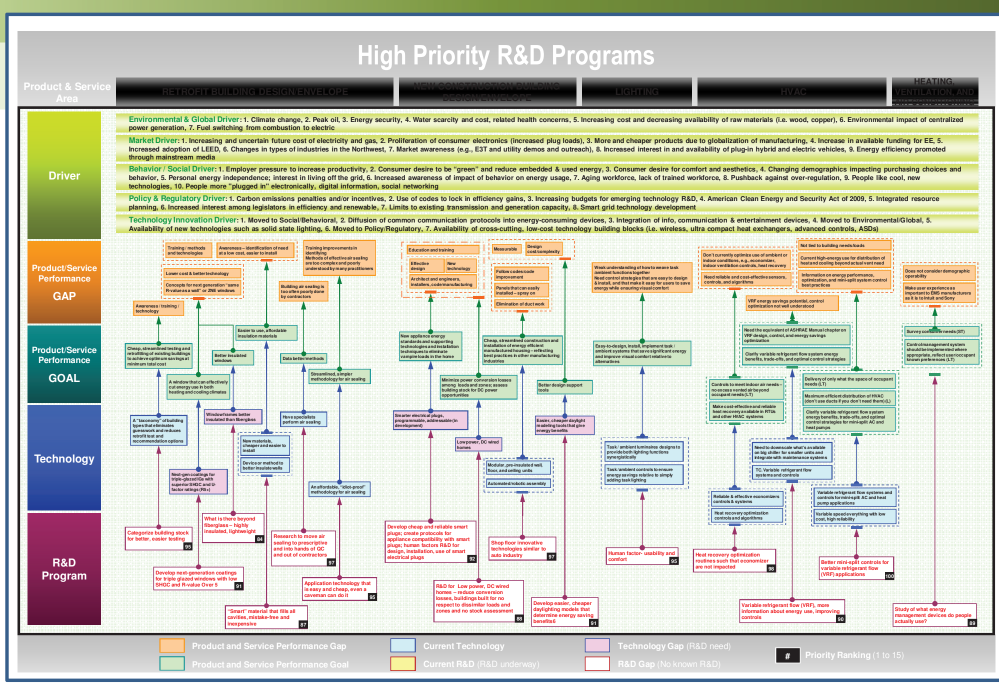
- Region-wide need to develop measures identified in the Council's Sixth Power Plan
- BPA and Northwest Energy Efficiency Alliance (NEEA) was tasked to establish a formal collaboration regarding their respective emerging technology programs
- Key results of BPA-NEEA collaboration:
  1. Formation of a regional emerging technology advisory committee
  2. Development of a regional energy efficiency roadmap to help in creation of a strategic regional research agenda

NW Regional Energy Efficiency Roadmap



NW Regional Energy Efficiency Technology Roadmap





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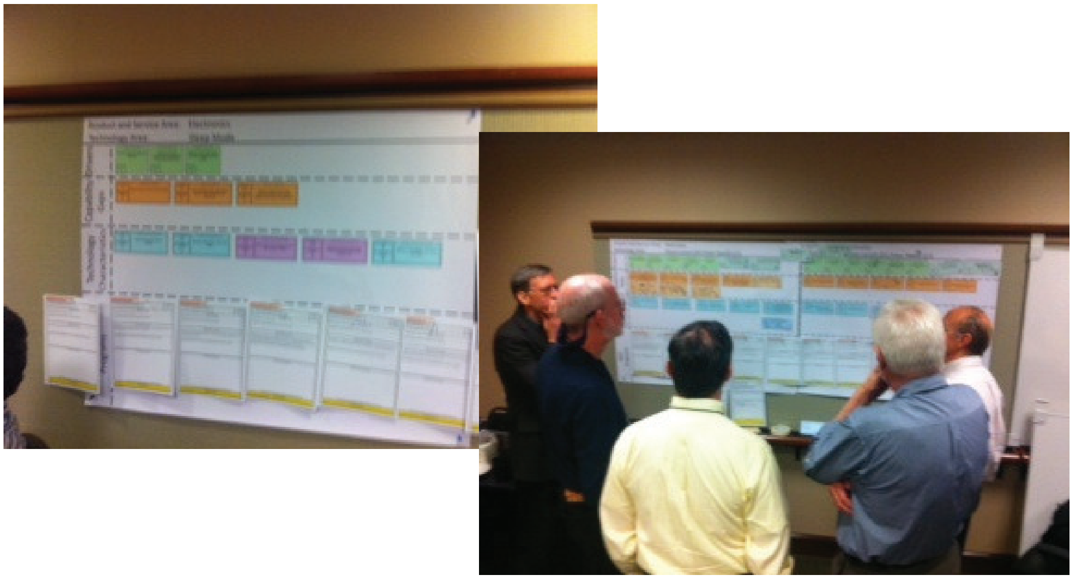
Key NW Learnings

- An agreed upon plan for strategic technology investments and market intitiatives
- Inclusion of all parties including government (federal and state) agencies, utilities, industry reps, national labs, universities and all related regional groups paved the way for coordinated policies and strategies
- The roadmap clearly highlighted the region's priorities, product and technology needs, gaps and investments to make to fill the gaps

National Energy Efficiency Technology Roadmap

- Held Technology Summit in Aug/Sept. of 2012
  - ~200 national/international experts for each P/S area
    - 5 roadmapping workshops in 4 days
      - Confirm/Revise existing content
      - Add short (0-5 yrs), mid-term (5-10 yrs), and long-term (10+ yrs) performance criteria
      - Prioritize P/S performance gaps
    - Interwoven with 3 days of panel presentations on existing R&D
    - Widened collaboration
    - Strengthened content of *Roadmap Portfolio*



TECHNOLOGY ROADMAPPING 101

Mechanics

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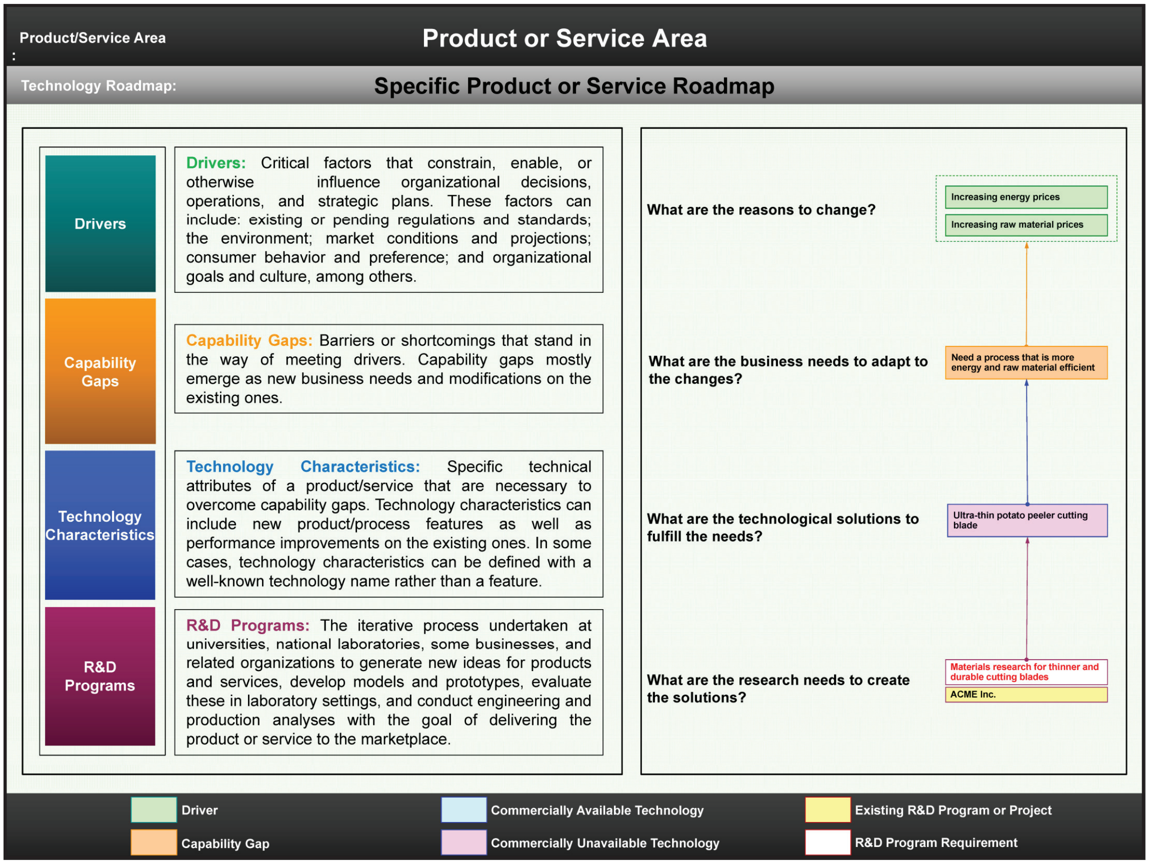
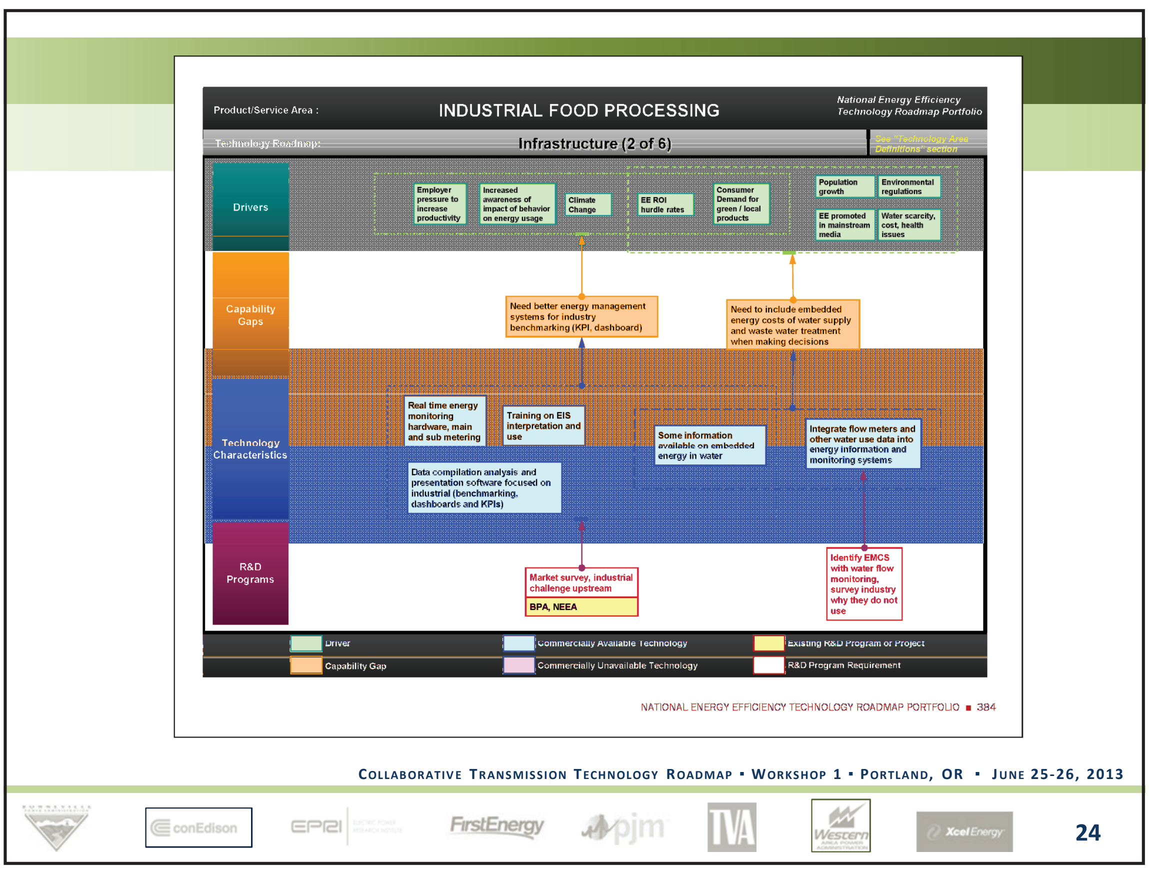
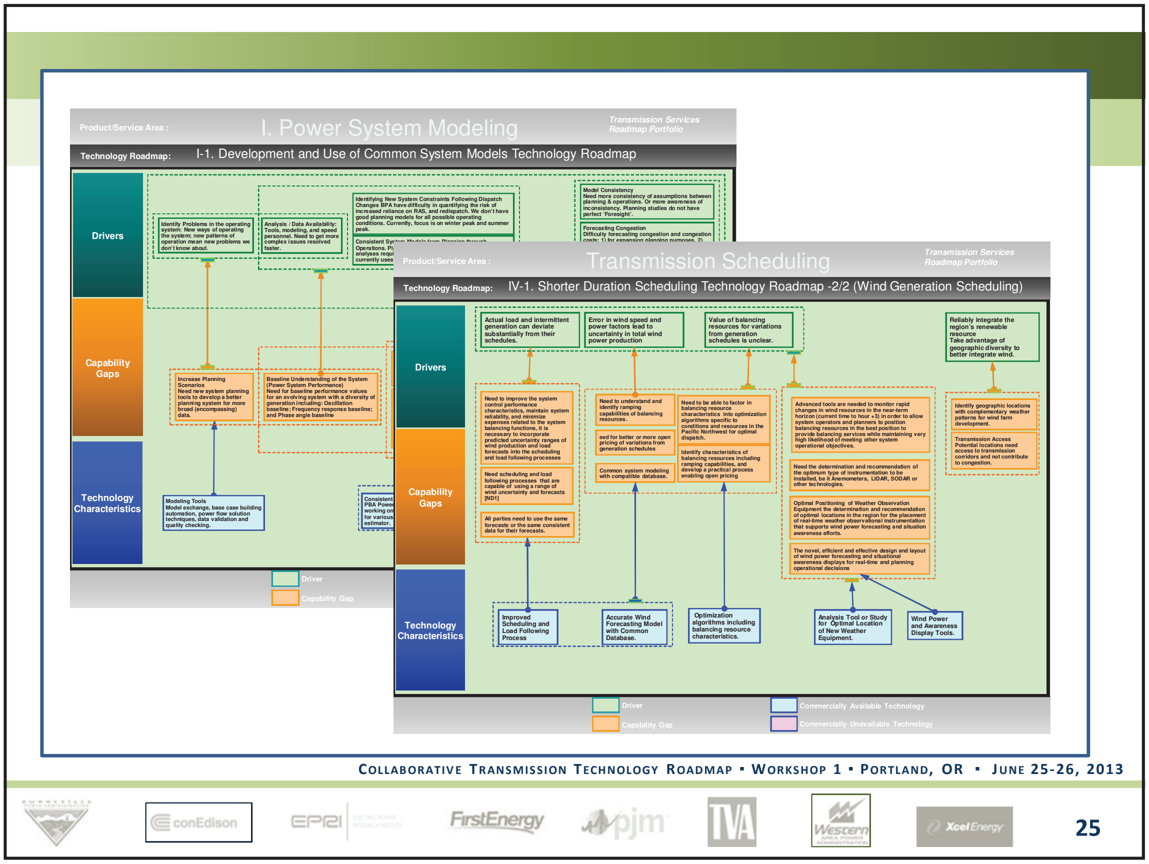
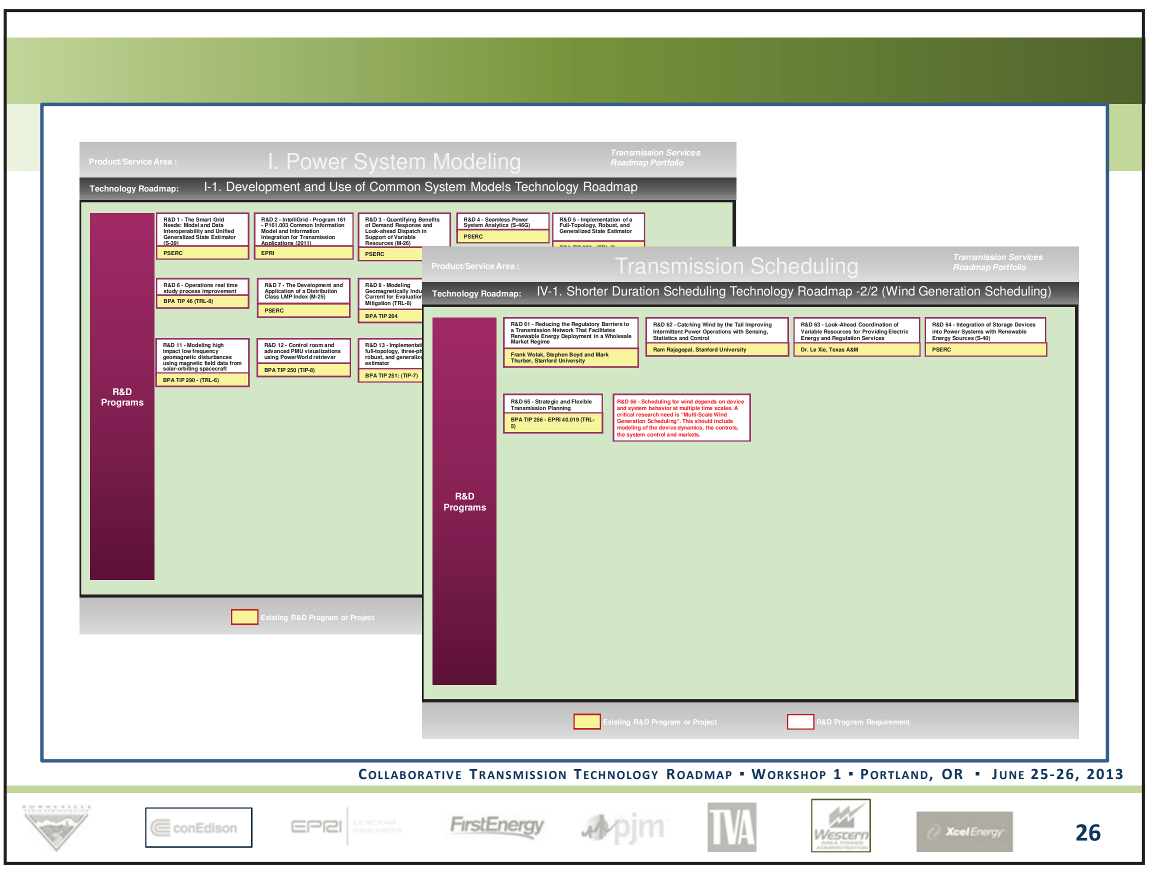


Product/Service Area
:
Product or Service Area
Technology Roadmap:
Specific Product or Service Roadmap
Drivers
Drivers: Critical factors that constrain, enable, or otherwise influence organizational decisions, operations, and strategic plans. These factors can include: existing or pending regulations and standards; the environment; market conditions and projections; consumer behavior and preference; and organizational goals and culture, among others.
Capability Gaps
Capability Gaps: Barriers or shortcomings that stand in the way of meeting drivers. Capability gaps mostly emerge as new business needs and modifications on the existing ones.
Technology Characteristics
Technology Characteristics: Specific technical attributes of a product/service that are necessary to overcome capability gaps. Technology characteristics can include new product/process features as well as performance improvements on the existing ones. In some cases, technology characteristics can be defined with a well-known technology name rather than a feature.
R&D Programs
R&D Programs: The iterative process undertaken at universities, national laboratories, some businesses, and related organizations to generate new ideas for products and services, develop models and prototypes, evaluate these in laboratory settings, and conduct engineering and production analyses with the goal of delivering the product or service to the marketplace.
What are the reasons to change?
Increasing energy prices
Increasing raw material prices
What are the business needs to adapt to the changes?
Need a process that is more energy and raw material efficient
What are the technological solutions to fulfill the needs?
Ultra-thin potato peeler cutting blade
What are the research needs to create the solutions?
Materials research for thinner and durable cutting blades
ACME Inc.
Driver
Capability Gap
Commercially Available Technology
Commercially Unavailable Technology
Existing R&D Program or Project
R&D Program Requirement



Product/Service Area :
INDUSTRIAL FOOD PROCESSING
National Energy Efficiency Technology Roadmap Portfolio
Technology Roadmap:
Infrastructure (2 of 6)
See "Technology Area Definitions" section
Drivers
Employer pressure to increase productivity
Increased awareness of impact of behavior on energy usage
Climate Change
EE ROI hurdle rates
Consumer Demand for green / local products
Population growth
Environmental regulations
EE promoted in mainstream media
Water scarcity, cost, health issues
Capability Gaps
Need better energy management systems for industry benchmarking (KPI, dashboard)
Need to include embedded energy costs of water supply and waste water treatment when making decisions
Technology Characteristics
Real time energy monitoring hardware, main and sub metering
Training on EIS interpretation and use
Some information available on embedded energy in water
Integrate flow meters and other water use data into energy information and monitoring systems
Data compilation analysis and presentation software focused on industrial (benchmarking, dashboards and KPIs)
R&D Programs
Market survey, industrial challenge upstream
BPA, NEEA
Identify EMCS with water flow monitoring, survey industry why they do not use
Driver
Capability Gap
Commercially Available Technology
Commercially Unavailable Technology
Existing R&D Program or Project
R&D Program Requirement
NATIONAL ENERGY EFFICIENCY TECHNOLOGY ROADMAP PORTFOLIO ■ 384
COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP • WORKSHOP 1 • PORTLAND, OR • JUNE 25-26, 2013
conEdison
EPRI
FirstEnergy
pjm
TVA
Western
Xcel Energy
24





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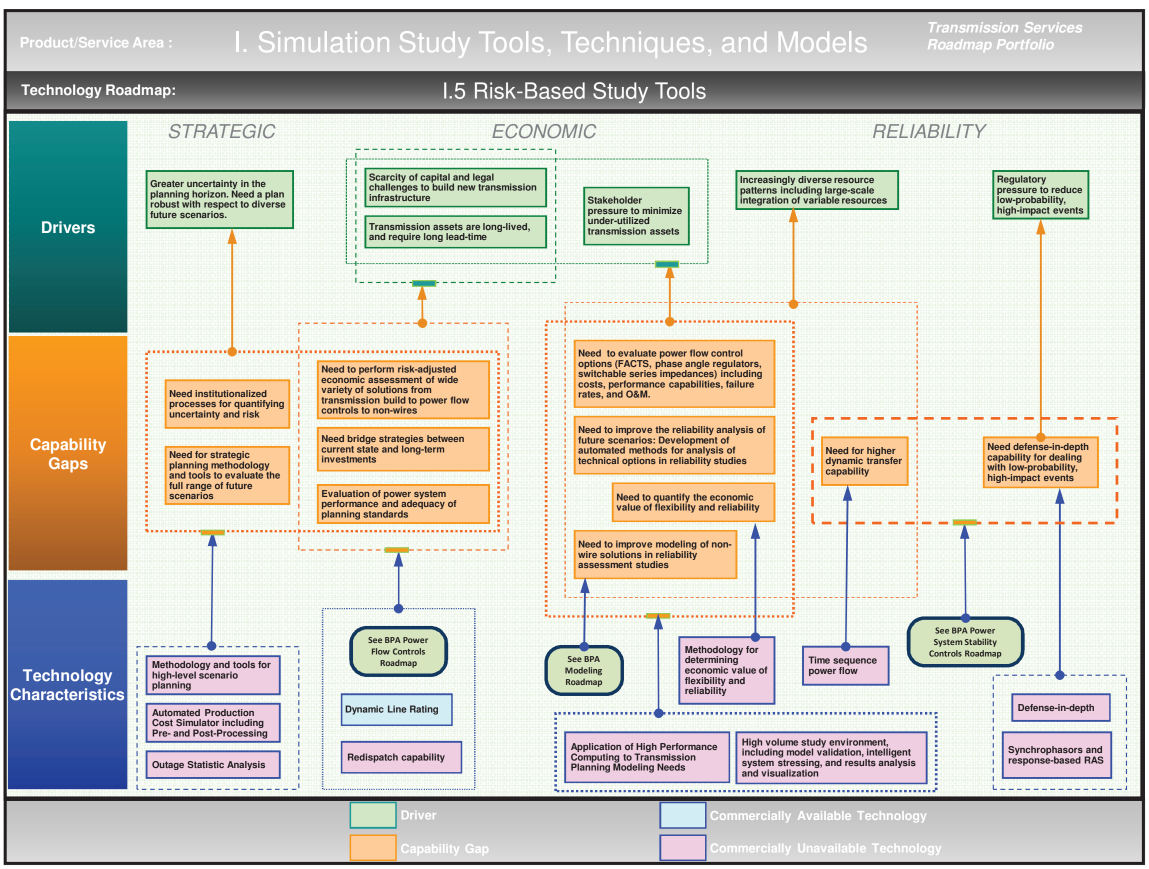
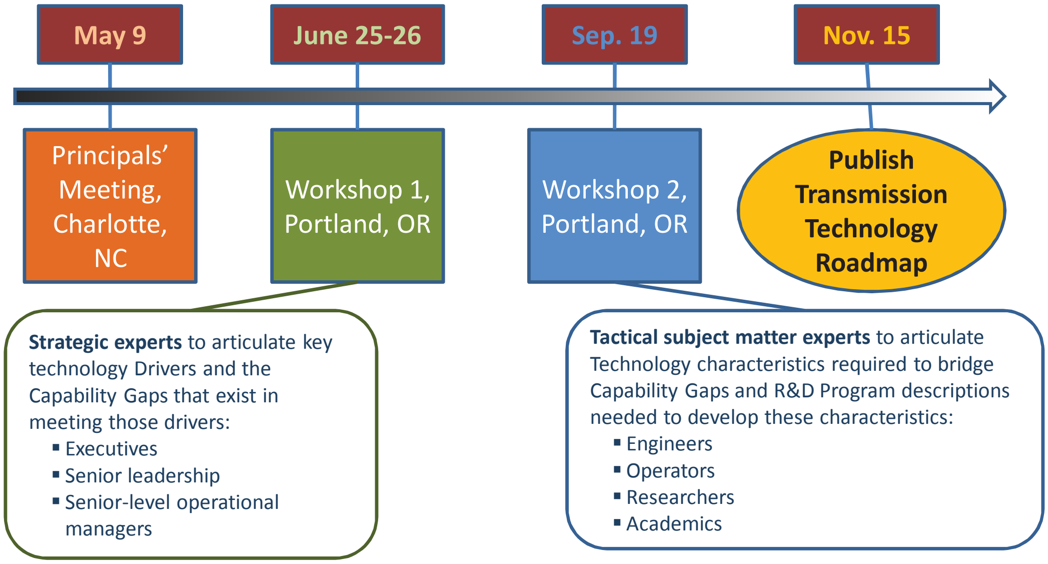
Specific Content Example



Project Tasks, Schedule, & Deliverables



Project Tasks, Schedule, & Deliverables

Workshop 1

Objective: Identify strategic Drivers and Capability Gaps for the high-priority Technology Areas selected at the Principals' meeting of May 9, 2013.

Tentative Schedule: Two-day workshop in Portland, Oregon, June 25–26, 2013.

Participants Sought from Collaborating Organizations: 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 transmission technologies to achieve the corporate strategy. These experts will provide input on the "strategic" levels of the roadmap critical in developing a resource that directly supports key business objectives.

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Project Tasks, Schedule, & Deliverables

Workshop 2

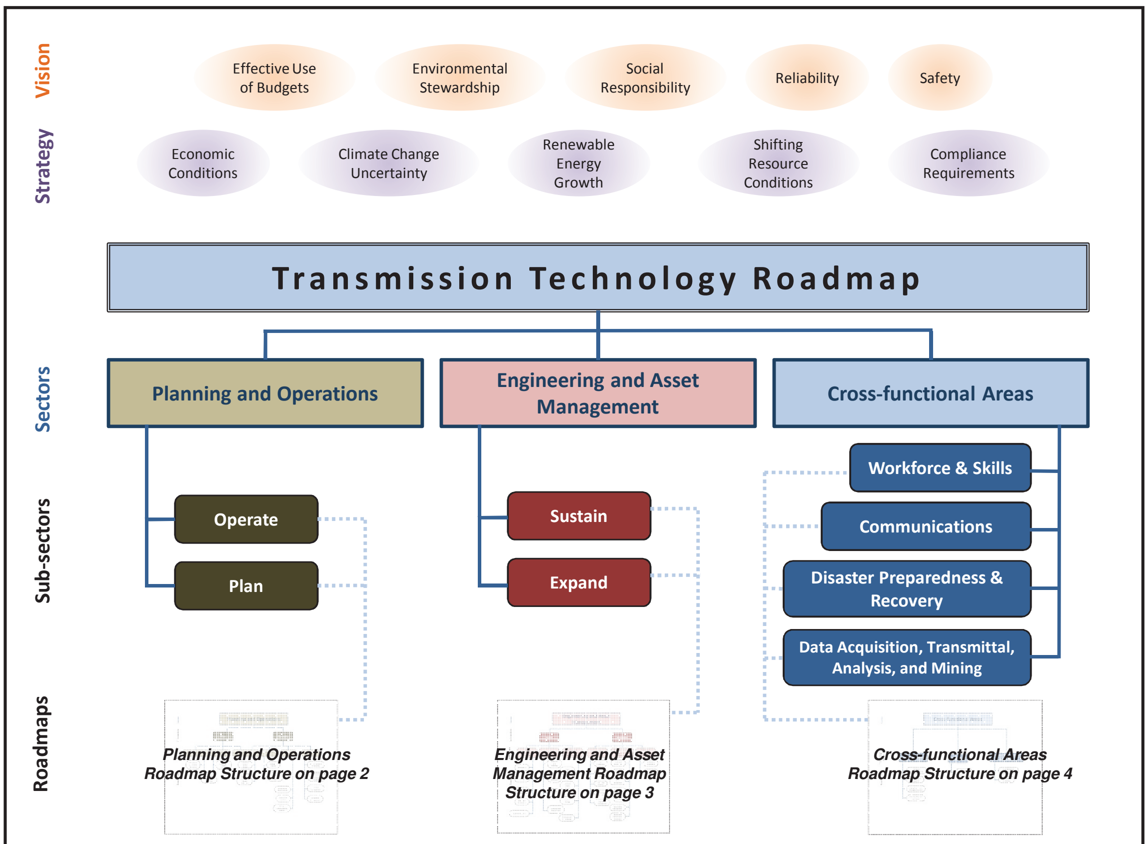
Objective: Within the Technology Areas selected at the Principals' Meeting, identify the Technology Characteristics and R&D Programs that address strategic Drivers and Capability Gaps identified during Workshop 1.

Tentative Schedule: 1-day workshop in Portland, Oregon, September 19.

Participants Sought from Collaborating Organizations, National Laboratories, Universities, R&D Organizations, and Vendors: Subject matter experts (SMEs) from throughout North America to develop the "tactical" content of the roadmaps—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 transmission technologies, models, algorithms, systems, etc.

- We are seeking to identify technology gaps which would require R&D – suggestions on policy or regulations are welcome, but please put them in the "parking lot."
- Groups should feel free to split or combine roadmaps as they see fit

- During workshop 1 we are looking from the top down – what are the business/strategic drivers in this area. Where are there gaps which technology may fill?
- During workshop 2 we will look from the bottom up – what technologies are available today, what technologies need to be developed, what research questions need to be answered?



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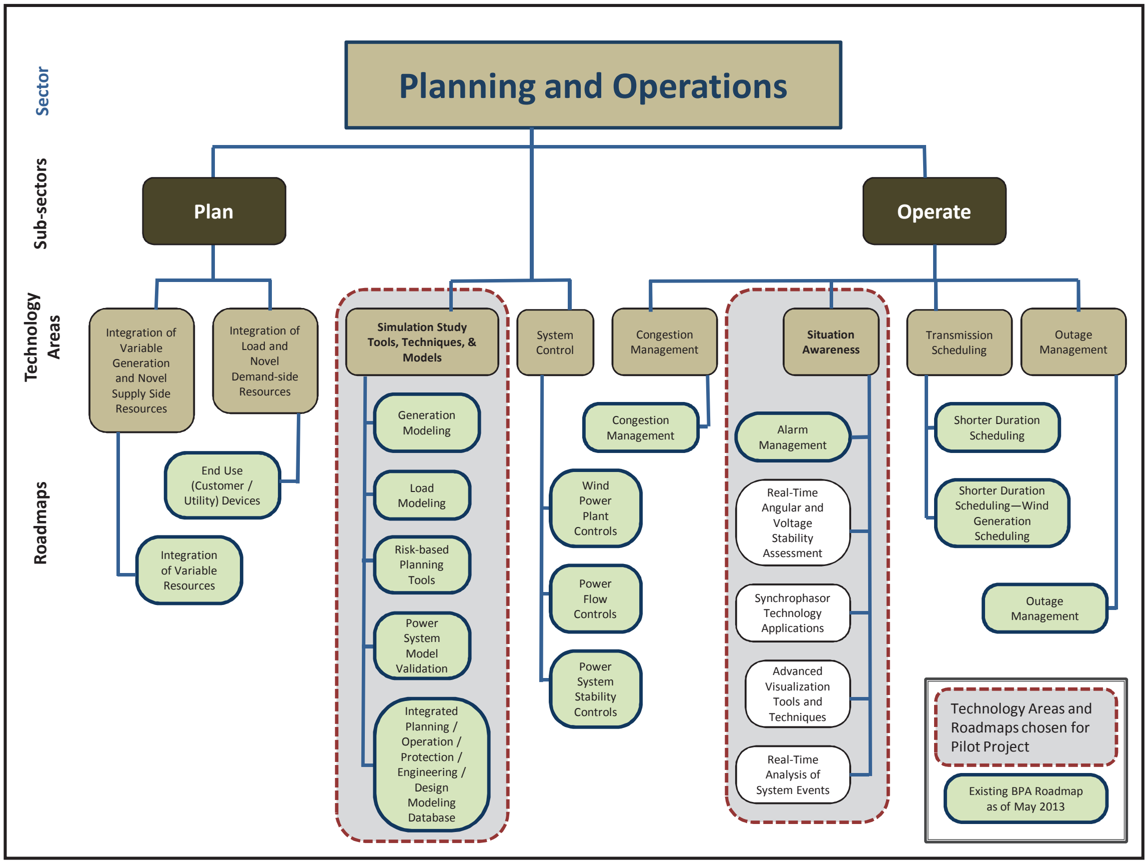
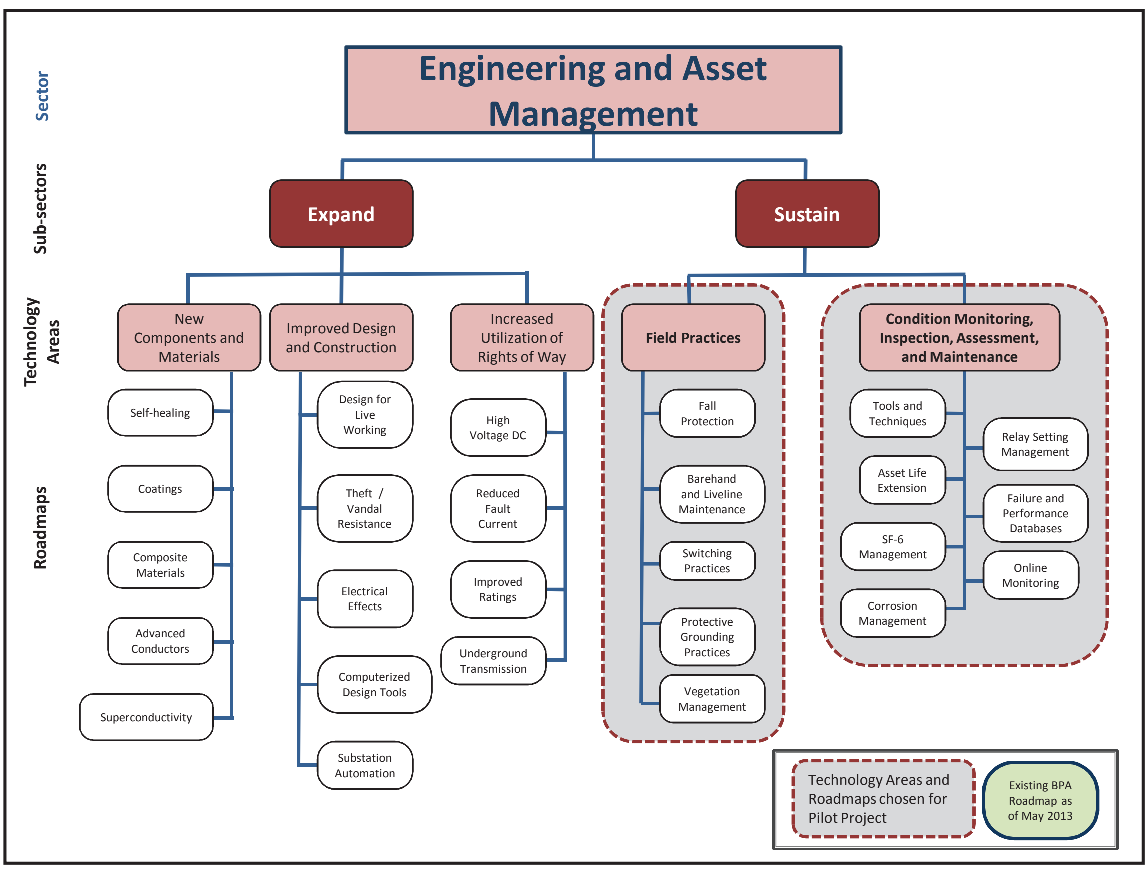
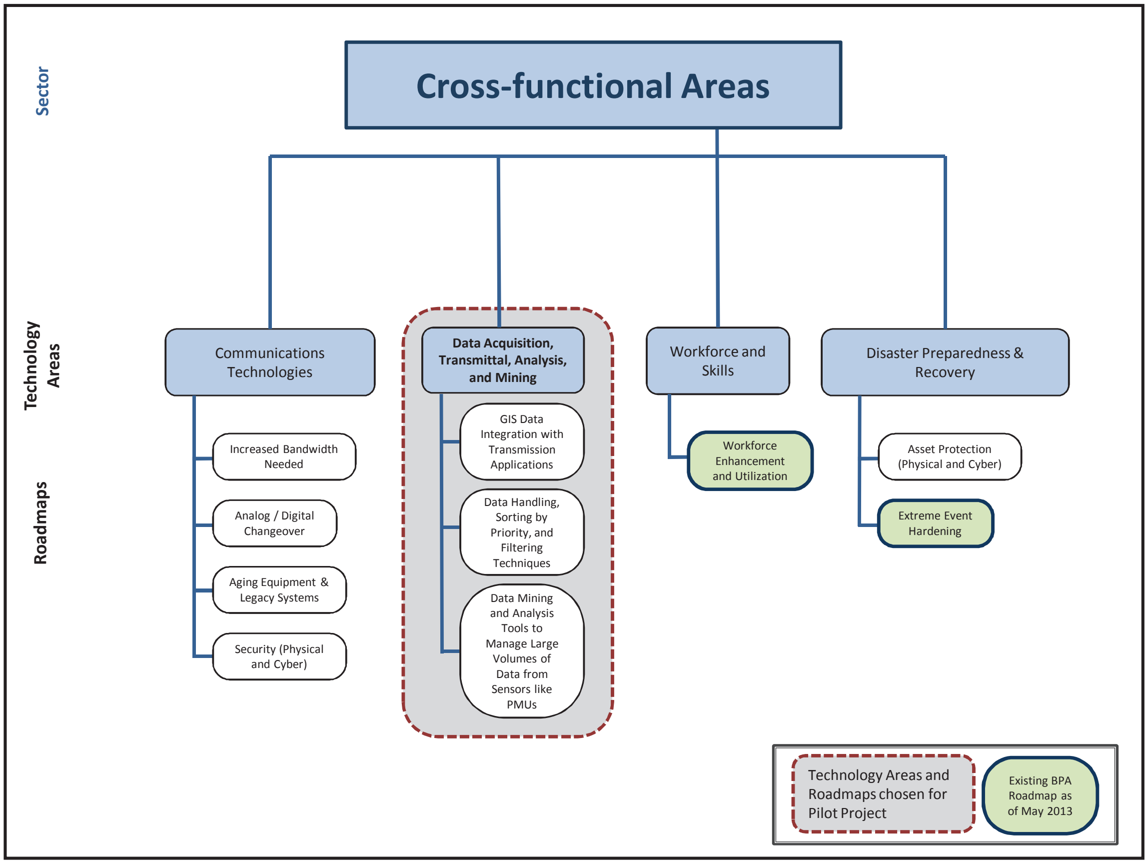

Sector
Sub-sectors
Technology Areas
Roadmaps
Planning and Operations
Plan
Operate
Integration of Variable Generation and Novel Supply Side Resources
Integration of Load and Novel Demand-side Resources
Simulation Study Tools, Techniques, & Models
System Control
Congestion Management
Situation Awareness
Transmission Scheduling
Outage Management
End Use (Customer / Utility) Devices
Integration of Variable Resources
Generation Modeling
Load Modeling
Risk-based Planning Tools
Power System Model Validation
Integrated Planning / Operation / Protection / Engineering / Design Modeling Database
Congestion Management
Wind Power Plant Controls
Power Flow Controls
Power System Stability Controls
Alarm Management
Real-Time Angular and Voltage Stability Assessment
Synchrophasor Technology Applications
Advanced Visualization Tools and Techniques
Real-Time Analysis of System Events
Shorter Duration Scheduling
Shorter Duration Scheduling—Wind Generation Scheduling
Outage Management
Technology Areas and Roadmaps chosen for Pilot Project
Existing BPA Roadmap as of May 2013


Sector
Sub-sectors
Technology Areas
Roadmaps
Engineering and Asset Management
Expand
Sustain
New Components and Materials
Improved Design and Construction
Increased Utilization of Rights of Way
Field Practices
Condition Monitoring, Inspection, Assessment, and Maintenance
Self-healing
Coatings
Composite Materials
Advanced Conductors
Superconductivity
Design for Live Working
Theft / Vandal Resistance
Electrical Effects
Computerized Design Tools
Substation Automation
High Voltage DC
Reduced Fault Current
Improved Ratings
Underground Transmission
Fall Protection
Barehand and Liveline Maintenance
Switching Practices
Protective Grounding Practices
Vegetation Management
Tools and Techniques
Asset Life Extension
SF-6 Management
Corrosion Management
Relay Setting Management
Failure and Performance Databases
Online Monitoring
Technology Areas and Roadmaps chosen for Pilot Project
Existing BPA Roadmap as of May 2013



TEAM ASSIGNMENTS

SA	ST	CM	FP	DA
Bart McManus	Anders Johnson	Alaina Redenbo	Al Choi	Pat Brown
Bob Austin	Daniel Brooks	Dave Cenedella	Chris Pardington	Joe Andres
Brian Tuck	Dmitry Kosterev	Doug Hunter	Jim Anderson	Joel Ankeny
DeJim Lowe	Don Watkins	Ivo Hug	Katie Sheckells	Linda Kresl
Jim Gronquist	Hamody Hindi	Mike Miller	Mike Staats	Michelle Odajima
Mahendra Patel	Ian Grant	Mike Simione	Sara Madugula	Stewart Larvick
Nick Leitschuh	Jason Espeseth	Richard Becker	Subhash Paluru	Tony Faris
Sean Erickson	Mark Tiemeier	Ted Carr		
	Ryan Quint			

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Next steps

- BPA, PSU, and EPRI teams to transcribe and process Workshop 1 output
- Convene practitioners, subject matter experts, and R&D community for Workshop 2 in Portland, OR, Sep. 19, 2013.

Closing

Thank you for participating!

Contact Info:

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rentriken@epri.com

Collaborative Transmission Technology Roadmap Pilot

Workshop 1 ~ June 25–26, 2013

Team presentations: Summary Insights and Conclusions

Executive Summary

The collaborative Transmission Technology Roadmap workshop was a great success with the following valuable outcomes:

- Participants spent one and a half days engaged in strategic forward-looking dialogue with their peers from distinguished utilities across the nation.
- Five technology areas of the collaborative Transmission Technology Roadmap, comprised of 23 individual roadmaps (listed below), were populated with business drivers and capability gaps.
- When the pilot roadmap is completed later this year, it will be used to guide investments in transmission research and to illustrate why it is important to invest in this area.
- The roadmap articulates areas of mutual interest offering the opportunity to better leverage future research investments.

Following is the concluding list of Technology Areas, as determined in the Principals Workshop, and within each area is a list of Roadmaps, as determined by Workshop 1.

I. Simulation Study Tools, Techniques, and Models

I.1 Integrated Planning/Operation/Protection/Engineering/Design Modeling Database
I.2 Power System Model Validation
I.3 Generator Modeling
I.4 Load Modeling
I.5 Risk-Based Study Tools

II. Situation Awareness

II.1 Alarm Management
II.2 Real-Time Angular and Voltage Stability Assessment
II.3 Synchrophasor Technology Applications
II.4 Advanced Visualization Tools and Techniques
II.5 Real-Time Analysis of System Events

III. Condition Monitoring, Inspection, Assessment, and Maintenance

III.1 Asset Life Extension
III.2 Corrosion Management
III.3 Relay setting Management
III.4 Failure and Performance Databases
III.5 Online Condition Monitoring
III.6 Fleet Management

IV. Field Practices

IV.1 Fall Protection
IV.2 Barehand and Liveline Maintenance
IV.3 Switching Practices
IV.4 Protective Grounding and Bonding Practices
IV.5 Vegetation Management

V. Data Acquisition, Transmittal, Analysis and Mining

V.1 Data Management for Non-Real Time
V.2 Data management for Real Time

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The next opportunity to contribute to the roadmap will be a second workshop in Portland on September 19th. Participants will populate the technology characteristics, R&D programs, and research questions that address the capability gaps identified during the first workshop.

Participants

Data Acquisition / Transmittal / Analysis / Mining

1) Joe Andres (Bonneville Power Administration)
2) Joel Ankeny (Bonneville Power Administration)
3) Pat Brown (Electric Power Research Institute)
4) Al Choi (Xcel Energy Services, Inc.)
5) Tony Faris (Bonneville Power Administration)
6) Linda Kresl (Bonneville Power Administration)
7) Stewart Larvick (Bonneville Power Administration)
8) Michelle Odajima (Xcel Energy Services, Inc.)

Situational Awareness

9) Bob Austin (FirstEnergy Service Company)
10) Sean Erickson (Western Area Power Administration)
11) Nick Leitschuh (Bonneville Power Administration)
12) Dejim Lowe (Tennessee Valley Authority)
13) Mahendra Patel (PJM Interconnection)
14) Mark Tiemeier (Xcel Energy Services, Inc.)
15) Don Watkins (Bonneville Power Administration)

Condition Monitoring, Inspection, Assessment and Maintenance

16) Richard Becker (Bonneville Power Administration)
17) Ted Carr (Xcel Energy Services, Inc.)
18) Dave Cenedella (Xcel Energy Services, Inc.)
19) Doug Hunter (Bonneville Power Administration)
20) Ivo Hug (Electric Power Research Institute)
21) Mike Miller (Bonneville Power Administration)
22) Alaina Redenbo (Bonneville Power Administration)
23) Katie Sheckells (Bonneville Power Administration)
24) Mike Simione (Consolidated Edison Co. of New York, Inc.)

Simulation Study Tools, Techniques and Models

25) Daniel Brooks (Electric Power Research Institute)
26) Jason Espeseth (Xcel Energy Services, Inc.)
27) Ian Grant (Tennessee Valley Authority)
28) Jim Gronquist (Bonneville Power Administration)
29) Hamody Hindi (Bonneville Power Administration)
30) Anders Johnson (Bonneville Power Administration)
31) Dmitry Kosterev (Bonneville Power Administration)
32) Ryan Quint (Bonneville Power Administration)

Field Practices

33) James Anderson (Bonneville Power Administration)
34) Sara Madugula (Tennessee Valley Authority)
35) Subash Paluru (Western Area Power Administration)
36) Chris Pardington (Xcel Energy Services, Inc.)
37) Mike Staats (Bonneville Power Administration)

Support

Navin Bhatt, Robert Entriken (EPRI)

James V. Hillegas-Elting, Jim Bowen, Terry Oliver, Judith Estep, Jeff Hildreth, Larry Bekkedahl, Jisun Kim (BPA)

Tugrul Daim, Joseph (Yonghee) Cho, Ibrahim Iskin, Edwin Garces, Dick Sterry (PSU)

Agenda for Wednesday, June 26

1. Welcome, Larry Bekkedahl
2. Field Practices, Subhash Paluru
3. Study Tools, Jason Espeseth
4. Condition Monitoring and Assessment, Ivo Hug, Mike Miller
5. Situation Awareness, Mark Tiemeier
6. Data Analysis, Tony Faris, Linda Kresl

Welcome, Larry Bekkedahl, SVP Transmission BPA

We are thinking about technology strategy and how it fits in on a daily basis. Industry has needed this kind of effort for a long time. In 90’s to 2000’s, we went our separate ways, and now we have learned our lesson about sharing. IBM, Terry Romeri says it is not about what you know, but about what you share. We want to know what R&D is out there and to know what is under each segment to know what is out there and what is pressing. We want to know how to get from point A to point B, by using the roadmaps.

There are things in the power sector, like power electronics, where we are falling behind the Chinese counterparts and we need to be leaders. Setting aside time to dream and to know how to take action on these dreams is what we appreciate from your efforts.

Thanks to Jeff and James and all those facilitating, there is a lot of work going on behind the scenes.

<u>Field Practices, Subhash Paluru</u>

We took a simplistic approach, by breezing through each TA first and then went back through each in detail.

Bare hand and Live line Maintenance, safety can be looked at in two different ways: One gap is that industry-wide knowledge needs to be shared. There could be a portal for sharing by region and each company can identify their practices. If we can improve the training for BH and LLM, there can be a reduction in accidents. There can be enhanced tools produced from learning and sharing. We can do research to understand the minimum approach distances. How can we equip existing tools to detect ?TBD? Hot line restringing can speed up installation, which is being done by TVA. Ian Grant explained this.

Fall Protection. WAPA accepted BPA practices for FP. It was accepted unanimously by vote in Reading. The gap is to develop tools and processes to prevent falls. Enhance existing safety tools. The full harness is difficult to embrace in the beginning. There are complaints about range of movement, but then they get used to it. Every utility has its own methods for safety and fall protection, so there can be standardized protocols. There is a need for tools.

Switching Practices. There is a suggestion from Chris to automate the switch practices in the subs. It would be nice to have the ability for both the operator and technician to see the same panel or look at the same SCADA stream. SCADA is automated, but how we get the screen displays is all manual through design and wire diagrams. Operating engineers validate and then the SCADA engineers work it up and test it. Sometimes, testing the wire diagrams fails and we need a way to automate this process. Enhanced simulation and automation tools could benefit from synchrophasor data and other detailed data sources. PG&E are using Areva 2.6+, where the plus signifies use of PMU data. They know the data is coming in, but they are still figuring out how to use the data. Jim Anderson mentioned that the corrected state of the parameters so the when the PSO desk will know the exact steps for switching. It will not matter how many different variations, they will still know how to execute. There is a need for standardizing the naming of devices, so that regions can share data. There is a need for additional succession planning.

Protective Grounding Practices. Some guys at the desk do not rely on SCADA voltage because they do not trust it. They rely on older methods. How can we correct that?

Vegetation Management. Why not use drones? Use high res cameras. Google and all those companies can identify objects in pictures. The trees are growing faster. Of course, improved LIDAR technology generates data, and that is one of the gaps. Jim from TVA said that a single conductor line could be made a duel conductor to improve throughput on a corridor. If you improve LIDAR, there will be a need for increased bandwidth. TVA came up with public education (TV ads) to teach people about vegetation management. Geotagging can tag in formation with coordinates. You can study your area and predict when to conduct management, based on a survey of the vegetation types.

I like switching practices with automation. So much time is taken for individual TWR. If there were a standing committee to review that would save a lot of time. This was Jim's idea, so maybe Larry can put him on a panel.

[LB] You talked about helicopter practices. [SP] We talked about that. [LB] Knowledge transfer seems we do not have the ability to work for long periods to develop skills. Education could concentrate that. Are there ways to accelerate the learning about new practices and equipment?

[Dave C] The substation field group is the biggest in personnel and O&M budget. Can we reduce that bill? Can we reduce substation inspection with the rest augmented with some technology? [SP] We did discuss that, like when you inspect for line size we can bring back data and analyze it. Drones could take pictures of lots of equipment at once to reduce visits. Switching practices could reduce human intervention. If they are all electronic and there is a standard committee to review, you can reduce man-hours.

[LB] How do we get to equipment that reports it own condition to reduce visits? We can cut down on inspections. [SP] EPRI showed us in Charlotte how a transformer can show its condition and communicate it through WIFI. [DC] You can change your field practices. [Doug Hunter] Security and copper theft is an issue. Can you do inspections more remote to reduce security issues? [SP] We had a few questions about the perimeter. We explained how we secure the perimeter and right now we are identifying the capability gap. There may be a need for a completely different area of CIP. It has its own scope of discussion. [DH] Our issue is physical security.

<u>Study Tools, Jason Espeseth</u>

There are four categories: Gen and Loads, Validation, Integration, Risk-Based Tools. If you can get it all on one platform, that is a good place to start. Right now, we do not have a single starting point. Right now let's get the database started. At Xcel we are starting on this, and industry wide there is nothing going on. Can you show that the model performs as in real life? Are all the right characteristics in the models? We spend billions on these models; let's make sure they are right. Let's emphasize better data. Is there an ?ACU on that line? This area covers from dynamic to long term planning. The industry is not there yet. There is a lot to do, but really how can we validate that it is true. The main drivers are NERC standards and ?TBD.

Generation Modeling. PV is still lacking. Solar is becoming more important. MN has a 1% mandate. We need to know how it reacts, how it works. I have surveyed utilities and almost no one can tell the breakdown of load (COMM, RES, IND). They have breakdowns, but do not have a way to validate that. We need a way to quickly validate this information. The start is to have a database. Are there tools to do this validation? Is there a test that takes a few minutes and can identify what data does not match?

Risk-Based Tools. Long leads and long life make transmission investment subject to high risks. The more and more renewables the different ways we have newer generation and reactive. It is no close to the load pocket and we do not know yet how to compare projects distance and close to load pockets. We need a super computer to change lots of scenarios to test these alternatives. In our region we look at 20 scenarios. We needed a tool that does this. Can we automate this thing? It will be really helpful.

[SP] Have you considered data accuracy? Yes. That's the biggest thing. Is it accurate, how do we know that it is accurate? Right now, we rely on experience to validate. [SP] The way you are measuring the data. Those devices can be made more accurate. Is 3% accuracy good enough? Does some data need to be more accurate? [JE] There is no way to validate the model without knowing what is out in the field. You kind of know what happened, and you can make the model look like your image of that, but is that correct? Did you change the right thing? [MP] One of the things I do not see is cascading outage analysis. How do you study beyond-criteria analysis. How do you know how far it is going to go? [JE] Benchmark your model to that? [MP] We do not have all the relays and controls modeled. How much needs to be modeled to know the size of the impacts? [Andrew] We have a gap on how to model HILF events. We do not model everything and we know there are risks for HI events that we do not know how to measure the risk.

[MP] Synchrophasors will provide disturbance data in a way not provided with existing systems. We need tests and point-on-wave data, to help with validation for extreme events. [DB] We put in a need for time-domain capture to cover that. We have 5 roadmaps of which 4 are on modeling. There is only one on tools, Risk-Based Tools. We tried to fit things into what we had. There may be follow-on to contract and expand these as appropriate. There are SPS and RAS to do deep contingency analysis. [DW] The WECC is discussing modeling of relays and RAS that is just crazy. Why do we not set that as an objective? [?] We did not have time. [DB] TransCARE is the approach we are using. Getting past N-2 is expensive. There is a need for supercomputers. It should be called out as an item we did not have here.

[MP] You can condense them to models and simulations. It needs faster models and CPUs. [BA] There are multiple modeling tools. You could have the system recognize that there are complex modeling tools. The sophistication of the modeling in the EMS. How do you marry tools to be on one platform? We use power network analysis of the EMS to do short term studies. How do we get PLSF and legacy tools with emerging tech to be all on the same page to compare different model outcomes. [JE] WE have node breaker and bus branch and it is hard to go from one to the other. [DB] There is a model of physical system accurately; you can generate the needed model.

Condition Monitoring and Assessment, Ivo Hug

We looked at monitoring, inspection, assessment, and maintenance. We changed the names of roadmaps and changed the meanings to fleet management and life extension. We created a new area on each of these. The roadmap for SF6 was removed because most of issues to manage this are complete. The roadmap for Tools and Techniques was merged with the remaining roadmaps.

Asset Life Extension. You do not have the right materials at the right time and need to extend the life of the old equipment.

Fleet Management. You need to make prioritization decisions about maintenance costs, the overall cost of assets, the consequences of failures. Overall fleet mgmt. includes an integration of conditions, consequences, and optimization of the overall cost. As a first step, you manage each device and as a next step you optimize subsystems. The key missing technologies are the algorithms and models to describe failure and asset behavior, and lots of the data about how equipment is failing is missing.

[MM, BPA]

Relay Settings Management. There is an ability to reduce operations and errors and mitigate the complexity of different relays, and mitigate the effect of shorter relay lives. Coordination is an issue. We added CIP and NERC and protection from unauthorized access and budget and getting qualified personnel. Ways to manage data that is simple for field personnel to deal with. One of them is the overall management of the relay system. Most of the work is handled out in the field without central coordination. We end up with lots of different manufacturers across the system and in single substations. We need a single process to manage all this equipment. With new CPU-based relays, it will be helpful to have a health assessment. Is there a way to extend life or design for predictable life?

[Mike Simione] A lot of expense is in replacing and maintaining high-voltage equipment. How do you know the condition and use that to schedule overhaul and replacement? How do we manage that? How do we control costs for O&M? To reduce cost, we need to do an investment. We want to go more to a probabilistic or equipment health system. We need an entire infrastructure to collect this data and technology to tell us what does that mean. Data tells us something and we need a system to help us decide what to do next. If this system is part of CIP we do not yet know how that fits together and is managed. How do we manage it to improve the existing conditions of what we have?

[Dave C] What is the cost effectiveness of getting this data? When the cost of the data management comes down, few will do this. We call the F150 method to drive around the pickup truck. Maybe that is the least cost solution. Most of this issue is fundamental blocking and tackling. We need the data. The challenge is to draw meaningful conclusions. How can we apply tools and techniques, like statistics and process quality control to tell that we are on a good trend to justify quickly the investments? This industry has the lowest level of QA/QC techniques used.

The new term is “asset attrition.”

[MP] Converting the condition to an operating limit. You cannot take the equipment out so you derate it. [MS] You could tie the health to operating requirements and limits. You need to balance risk of shutting down load.

[DB] Did you discuss use of detailed data to look at operational settings and identify misoperations? [DC] That sounds great. We did not get into that. We ran out of time.

[RB] There are bits and pieces, like the self-diagnostic substation. The relay settings can be configured by hand, and there are incorrect settings from human error. How can we identify them from an event? If you can build that from data import and assess QA. [MS] Three groups work on this from design, settings, and implementation, if you can have this done more automated that was one technology gap. [IH] Overcoming the silos of planning, relay setting, and protection. [DC] We have 40+years of electro mechanical, and we think that we need a new technology to get more life from processor-based relays. [MP] Many processor relays are multi-functional, and some preset / default settings are sources of setting errors. [DC] We have seen firmware updates add features that we did not want.

Situation Awareness, Mark Tiemeier (Xcel)

SA is defined by looking at Wikipedia today. It had some pretty good insights. It is about being aware of the existing events occurring on the system. How do we give the operator tools to understand and make decisions? I manage operators, and they know there are lots of ways to poke a hole in an argument, but they need a way to make quick decisions.

Alarm Management. This is crux of the information gap for an operator in SA. If nothing is consistent, how do you know what is important. We need to synchronize time stamps to know what happened first. Alarms need to be ordered in time and automatically processed.

Synchrophasor Technology Applications. The biggest gap is the infancy of the technology. It has been available for a handful of years. What do we do with all of this data? We have two people looking at the data coming in and we do not know what to do with it. How do you take this data and use it. Sub-sectioned data is not as important, as getting the GPA time stamps and the latency on the data when you need it. The grid is a lot more dynamic. We are generating more electricity further from load; we need a lot more power transfer that leads to stability situations that are new. PMUs make us aware of oscillations that we never realized that were there. How do you take that and make use of it? Modeling is understandable for validation. How do you tell that to an operator who does not do that? How do you have a green, yellow, and red to communicate to an operator?

Real Time Angle and Voltage Stability. These have been studied and on the planning side. The challenge is to move this into operations. Operators need to know about theses stability problems. We do not have great tools in place to show operating limits. We are operating within boundaries and not maximizing system utilization. How do we take off-line studies and get them into operations. We may want this done in the EMS. Right now data is taken out of the EMS and then put back in. How can the implementation be made simple?

Advanced Visualization. For years how we operated with SCADA and EMS looking at MVARS KVA; we need to go on to the next level of parameters. Can we continue to use these parameters to identify new issues? Do we need new parameters? This goes back to information overload. Can we pick a list of the most important issues? Doe not include the noise, low-order things. Improve the analytics. We rely on experience and brainpower. They can see parameters change and know the impact. Experience is going out the door. Younger less-experiences operators need to speed up their experience and learning. Can these tools do that? Training tools, dispatch training simulators, get new employees to go through simulated events. How can we use health monitoring to help the operator, like end-of life estimates to change operating limits?

Real-Time Analysis of System Events. The way we look at Visualization and Event Analysis, the first is heads up display, and the other is analytics. There is a lack of high-speed communication to remote sites. Some sites are not observed and the SE may not converge properly. This affects the accuracy of data for decision-making. Expansion of models to neighbors was brought up in the San Diego blackout. Here is a need for trust in the numbers. Operators ignore results that are not trusted.

Parking Lot. Some policy things are in there.

[DW] The bottom line is to avoid blackouts. So all of the stuff we were doing has to do with doing that. Synchrophasors provide a way to get data and the applications are about supporting decisions. We look backwards in operations and would like to have information about what is coming. We look at past blackouts and try to learn, but the next one will be different. We need to have a way to know that something is not quite right. The 96 and 2003 events had lots of clues. We need some way to collect those clues and detect them.

[TO] Is there an instant replay function? This can be done at the end of a shift to replay four things? [BA] we have some advanced capabilities. We are aware and use the EMS to capture events. Taking that event into the wide system and quickly turning it over to a training simulator is possible. The offline tool can run the event with the same people in order to relive the event starting with the alarming function. We capture a week of information to the point where we can replay it. We very often get requests from planning and protection. They like to see how the alarms came in and what the values were. There is some second-guessing the operators, but it is mostly a planning exercise. The tools have been worked by EPRI to expand work in this area. That is part of situation awareness. It is part of our roadmap. It is not going away.

[DW] Does the replay result in differences? We get 500 alarms. We get alarms like planning file capacity. That comes through in terms of what alarms should go to operators. There needs to be a complex assessment of alarms and logic. Operators cannot approve 150 alarms and recreate in his mind the sequence of events. There needs to be a filter for what is needed to know right now. During DTS scenarios, we identify alarms that the operator never saw, because he was focusing on something else. 40 years ago, the system was not made to do today's work. It is pretty sophisticated.

[SP] You are expanding the model; we are too. The data is transferred with ICCP. Are you considering new network technology? [Mark] We did not get into better technology, but we did discuss loss of ICCP and how that affects being able to make decisions.

<u>Data Analysis, Tony Faris, Linda Kresl</u>

We went to the lower-case drivers. We scrapped the original roadmaps because of overlap in drivers and gaps. We decided to break up the roadmaps by real-time (seconds to minutes) and by non-real-time. Drivers for non-real time are ROI and workforce investment. Watching data trickle in is not efficient. Is there a method a model that is best practice for retrieving data? Data mining is a huge gap in what we are doing right now. We have a 200TB archive and want to dig through that. Coming up with a good way to do that is a huge problem. Retrieving data from multiple sources is great, but not efficient to access from one place. Overlay of all data to an operator in one display is not possible right now, because of multiple systems. How do we change the culture to still follow regulations and requirements and CIP and still get work done? (Parked)

O&M Improvement. Getting validated data and knowing that a device is failing do not drive a lot of relay maintenance. The difference between SCADA data and synchrophasor data is to understand how to use them together to assess health. We compare multiple sources and detect problems with one. Can we get the data when, where, quickly validate and use it? Are there algorithms to encapsulate experience?

[Linda Kresl, BPA] There is common language among the Technology Areas. The quality of the data is the key. Duke Energy is borrowing from other industries to assess data quality. They are using Tableau. (She shows an iPad example.) We need to take this data and make it understandable. Data visualization is something we can achieve with this roadmap.

How do we achieve this data quality? People, Process, Tools, and Standards. Data may be correct to one group and not to another. Solve in multiple layers. Use cultural changes to appoint data stewards.

BPA has 200TB to store. Should they use ADIABA or HADOOP? Do we use click-stream analysis? Can we trickle feed real time data and explore this with the roadmap. I have done this with aerospace and banking and we can do this here. ISO 8000 is a new standard for data quality. Xcel and BPA are looking a consistent naming and create the metadata that gives an audit trail. Moving data across systems allows you to see what is happening. We can work with NERC and FERC data dictionaries. Reuse this.

Data entry is part of quality. Fat Finger?? There can be data checks for allowable data and completeness. Validation should be immediate and fed back. Validate at the app layer and the database layers too. The database will be profiled. The BPA tool is called Informatica, and shows you 200 MB anomalies. We need to decide which data is most critical for cleaning.

Boeing merged TQM and DQM to make the Boeing 787. The plane and its manuals were delivered together.

[DeJim] Consider long-term data handling across multiple location and end user. What kind of computing system do we need? [Jim Anderson] We do not yet have an answer. There are giant databases for real-time access. Part of the issue is that right now we have disparate databases and getting it into a single repository is non-trivial. How to keep security, networking, and hardware issues? Is anyone spending time on this at the agency? Xcel is using Terradata. Walmart is using Terradata. They wanted to be the number one retailer of "value." They have a huge data quality department as well.

Natissa is a large database. TMobile uses it. These databases are expensive and you need to document your data requirements.

[DC] How do we define R&D? With data and monitoring, we need a white paper to establish value and payback. It is hard to get this message across. [JH] R&D is "rip off and duplicate." Our definition is loose that includes demonstration and deployment.

There needs to be a demonstration before we get buy-in. [TO] We set up an opportunity for a project that is an end run around some kind of capitalization project. Hydro Quebec is a member of IBM's smarter energy institute using massive compute power and data analysis. In this process they think they can prove the value of bigger iron. At BPA, is there a choice of architecture and the rest of the system? Let's set up a competition and see how the various systems perform. The past had large systems with large safety margins. Can we get faster more lean systems?

[DB] There is value in collaborative sharing of cost/benefit of the various demonstrations. Each utility will have a different configuration and the lesson sharing has R&D value. Each one can have standards for implementation and sharing.

[SP] WAPA had an issue with data. We had OATI, web, and PI data serving transmission, operations, and power marketing. We had a vendor and open source called TIBCO. They implement a pipeline with a subscription process to connect into the data bus. Once you subscribe, you say that this customer management system is unique and is defined within the bus. You say that you need XYZ data and the only thing you need to do is define the recording. Now we are looking at the model side of it.

Today the power marketing and business in S&R and transmission and operations are all subscribed into the data. The key is to buy into the new server and once we got that it made our lives easier.

<u>Data Analysis Presentation, Navin Bhatt and Pat Brown (EPRI)</u>

We looked at data related issues in each of the TAs. We hear, "We don't want data. We want actionable information." The example in Field Practices was LIDAR and how to use information. Systems Studies had data for planning, operations, and protection. Condition Monitoring has sensor data and analytics for maintenance. Operations Awareness has synchrophasor data. Each of the teams identified data issues.

[PB] The three fundamental themes where work can have benefit are network model management, asset health modeling, and substation data gathering architecture. Network models show up in planning and ops, in state estimation and visualization, and in geocoding and veg mgmt. The second area is asset health gathering wide-ranging data and historic and real-time data. Testing and maintenance data should be organized for analytics. Control center wants to know de-rates and emergency rates. The third is substation data gathering architecture form configuration management, setting validation, getting operational info, and store local or central. Solution can be more cohesive and comprehensive.

61850 was not mentioned. We need to know the broad scope of needs on architecture. Each one needs technology application and cross-silo demonstrations.

[JH] Should Data Management and Analysis be treated separately?

[RB] Some is separate, but the common part should remain visible.

[IH] We are in the business for a long time. GOP is always about data and algorithms. What is new? Can we proceed on the same path? Do we need new methods or is it about sharing? Looking at the areas, it is about making good decisions based on data. What do we need to change?

[Alena] One of the big problems is data integration and aggregation. We need a roadmap that builds a foundation and then builds on it.

[DC] Address distinguished colleague from California. How much focus do we need on the data? Should it buried in silos or is there a cool aspect in sharing? EPRI can research what other industries do to share. [JH] What is the dollar value of having data organized and accessible? [DC] Yes. Others may have this figured out better than we do. [LK] Data practice is better organized across industries. They are still analyzing data. How you define it and use it is common across industries. Share standards that are already there. Promote them and make people more aware.

[Xcel] We want to know how it improves productivity.

[AC] IT / OT integration is not a transmission or distribution deal. It is an enterprise deal requiring a cultural change. We have Terradata and use it for other applications. You need to use it for big things.

[DC] We have an issue with a new system without thought on the data, which remains as good as it was. Why not get value out of new system? Focus on data.

[DW] The industry uses PI, which stacks data. Do we drop PI? Should it be a front end to Terradata? [MO] We have many systems, and still know that it is garbage in garbage out. Data can be missing or fat fingered and inaccurate.

[DH, BPA] Data Management needs to be a separate roadmap, because a lot of the issues were due to silos.

[JH] What action to take now?

[PB] Focusing on DM at the executive level is good. I am a believer in incremental change and having a portfolio. Look at every project and be intentional about the approach, whether slapped together or foundational and extendable. Look at the overlap and consider pulling in expertise from other industries and propose a broader solution. Your program offers that opportunity. [AC] When is it a transmission project or an IT project? It is a champion item that comes form the top. Having worked on Smart Grid City, we worked on a broad architecture. We are about keeping the lights on. Unless there is a new paradigm, we focus on reliability.

[JH] We have an EE roadmap. I am hearing that we need an Enterprise Data roadmap. This is broader than transmission. [TF] We want to make this great system to prove that data access is valuable. We don't have support and wind up will little niche projects. Does that mean we need an R&D project to show that all of the little projects can be solved with one solution. [TO] What ever is done should have the potential to scale to the enterprise. If you can, then you can add elements to achieve the scale.

[HH] What is our tolerance of poor data? A next step is to quantify how much bad data is worth seeing.

[Doug] How do you design an architecture if you don't know what you want? Keep an eye on the needs and do not get caught on tangents that are not useful.

[IH] A demonstration is to show that you can do something at scale. For example, 5MW carbon capture is easy. To do it for multiple power plants is hard. One substation is easy, but the whole WECC is hard. It is transmission or data? I was asked to decide the difference between Intelligrid and Transmission Research. We looked at the data model. If it is on the left it is data and on the right side is the domain. You can only get to the right data with integration. We are always looking at the right line between data and domain.

[DC] We want to know the business value of the Data Management investment. Should it be physical or market research? How have others been able to get their data to be 95% accurate?

<u>Next Meeting</u>

Workshop 2, 19 September, Portland, OR.

Section 4

Workshop 2: Technology Characteristics and R&D Programs, August 27 & September 18–19, 2013

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COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP

PILOT PROJECT

MINI WORKSHOP 2: ENGINEERING & ASSET MANAGEMENT TECHNOLOGY CHARACTERISTICS AND R&D PROGRAMS

Aug. 27, 2013
EPRI Facility
Charlotte, NC

Objectives

1) Develop consensus on teams and approach
2) Review, revise, and identify Technology Characteristics and R&D Programs
3) Team presentations: Summary insights and conclusions

Agenda

9:00 a.m.	**Welcome, logistics, & introductions** **Overview of workshop objectives & roadmapping process**	Jeff Hildreth, BPA James Hillegas-Elting, BPA
Objective 1	**Develop consensus on teams and approach**	
9:30 a.m.	**Review draft roadmap structure** **Determine teams & establish strategic approach**	Jeff Hildreth, BPA
Objective 2	**Review, revise, and identify Drivers and Capability Gaps**	
9:45 a.m.	**Identify Technology Characteristics linked to Capability Gaps** **Focus Question:** What are the core characteristics of a piece of equipment, a tool, an algorithm, a software program, or other technology that would help address the linked Capability Gap(s)? **Identify R&D Programs linked to Technology Characteristics** **Focus Question:** What are the core elements of an R&D program that would be designed to deliver the linked Technology Characteristic(s), including a summary description and one or more key research questions?	Workshop Participants
11:45 p.m.	***BREAK FOR LUNCH***	
1:45 p.m.	**Continue Objective 2**	Workshop Participants
Objective 3	**Team presentations: Summary insights and conclusions**	
3:00 p.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
4:00 p.m.	**Conclusion & Next Steps**	Jeff Hildreth, BPA
4:30 p.m.	**Adjourn**	

Project Partners: *Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy ▪ PJM Interconnection ▪ Tennessee Valley Authority ▪ Western Area Power Administration ▪ Xcel Energy*

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PILOT PROJECT

WORKSHOP 2: TECHNOLOGY CHARACTERISTICS AND R&D PROGRAMS

Sep. 18–19, 2013
DoubleTree Hotel
Portland, OR

Objectives

1) **Day 1:** Develop consensus on teams and approach
2) **Day 1:** Review, revise, and identify Technology Characteristics and R&D Programs
3) **Day 2:** Team presentations: Summary insights and conclusions

Agenda – Day 1

8:00 a.m.	**Welcome, logistics, & introductions** **Overview of workshop objectives** **Overview of roadmapping process**	Larry Bekkedahl, BPA Terry Oliver, BPA Daniel Brooks, EPRI Jeff Hildreth, BPA James Hillegas-Elting, BPA
Objective 1	**Develop consensus on teams and approach**	
9:30 a.m.	**Review draft roadmap structure** **Determine teams & establish strategic approach**	Workshop Participants
10:00 a.m.	***BREAK***	
Objective 2	**Review, revise, and identify Technology Characteristics and R&D Programs**	
10:15 a.m.	**Identify Technology Characteristics linked to Capability Gaps** **Focus Question:** What are the core characteristics of a piece of equipment, a tool, an algorithm, a software program, 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
11:30 a.m.	***WORKING LUNCH**: Review activities / results from morning session*	
12:00 p.m.	**Continue Objective 2**	Workshop Participants
4:30 p.m.	**Conclude Day 1 and prepare for Day 2**	Jeff Hildreth, BPA
5:00 p.m.	**Adjourn**	

Project Partners: *Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy PJM Interconnection ▪ Tennessee Valley Authority ▪ Western Area Power Administration ▪ Xcel Energy*

COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP

PILOT PROJECT

Sep. 18–19, 2013
DoubleTree Hotel
Portland, OR

WORKSHOP 2: TECHNOLOGY CHARACTERISTICS AND R&D PROGRAMS

Objectives

1) **Day 1:** Develop consensus on teams and approach
2) **Day 1:** Review, revise, and identify Technology Characteristics and R&D Programs
3) **Day 2:** Team presentations: Summary insights and conclusions

Agenda – Day 2

8:00 a.m.	**Welcome & Check-in**	Jeff Hildreth, BPA
8:30 a.m.	**Prepare for team presentations: Review of Day 1 output**	
9:30 a.m.	***BREAK***	
Objective 3	**Team presentations: Summary insights and conclusions**	
9:45 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 a.m.	***WORKING LUNCH**: Continue team presentations & group discussion*	
	Continue Objective 3	Workshop Participants
11:45 a.m.	**Wrap-up & next steps**	Jeff Hildreth, BPA
12:00 p.m.	**Adjourn**	

PILOT PROJECT

WORKSHOP 2: TECHNOLOGY CHARACTERISTICS AND R&D PROGRAMS

Sep. 18–19, 2013
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1) **Day 1:** Develop consensus on teams and approach
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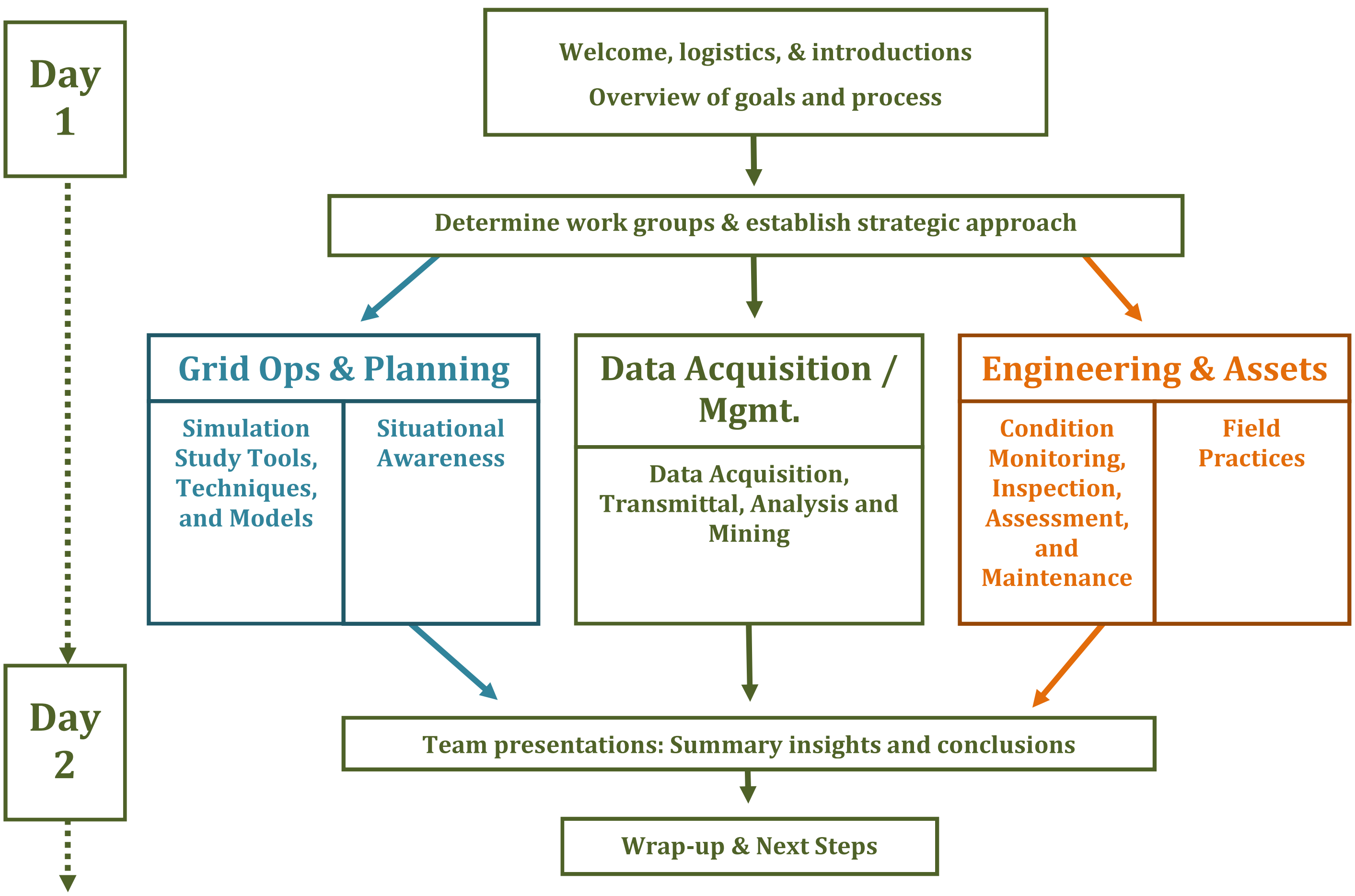
Agenda – Schematic



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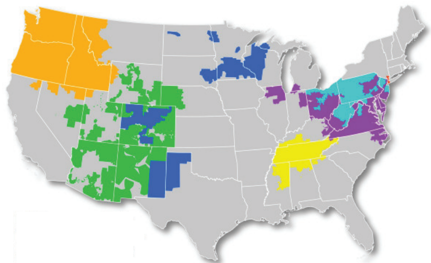
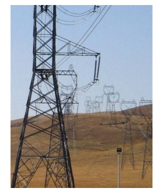
Collaborative Transmission Technology Roadmap

Mini Workshop 2: Engineering & Asset Management Technology Characteristics and R&D Programs

Charlotte, NC ▪ August 27, 2013





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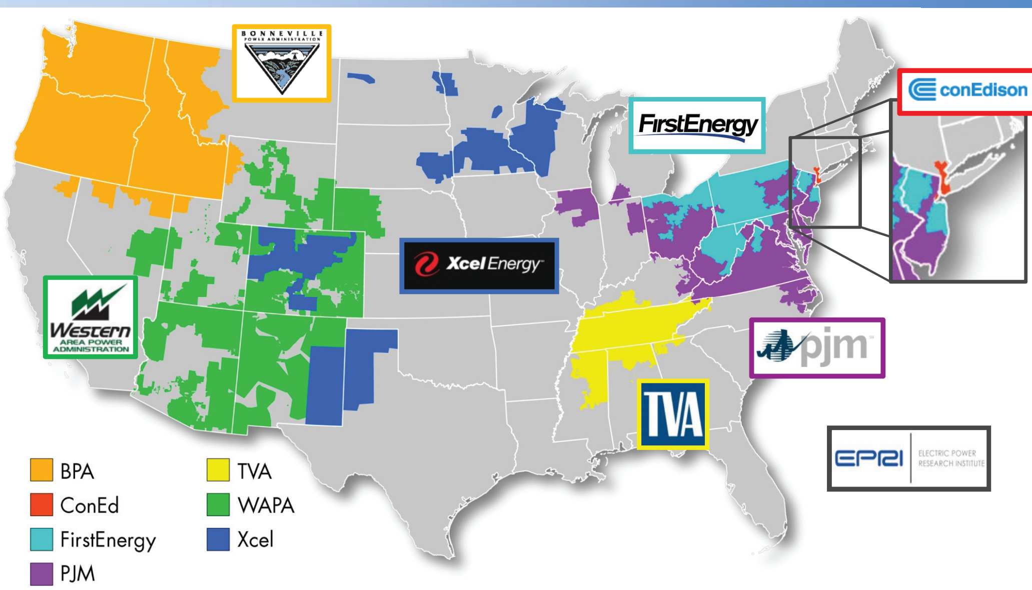
Service Territories



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OBJECTIVES

Build upon the output of Workshop 1 to:

1) Link Technology Characteristics with identified Capability Gaps, and
2) Articulate R&D program descriptions and key research questions to develop the linked Technology Characteristics.

AGENDA

9:00 a.m.	Welcome, logistics, & introductions Overview of workshop objectives & roadmapping process	Jeff Hildreth, BPA James Hillegas-Elting, BPA
Objective 1	**Develop consensus on teams and approach**	
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4:00 p.m.	Conclusion & Next Steps	Jeff Hildreth, BPA
4:30 p.m.	Adjourn	

ROADMAPPING AT BPA & EPRI

TECHNOLOGY ROADMAPPING

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.

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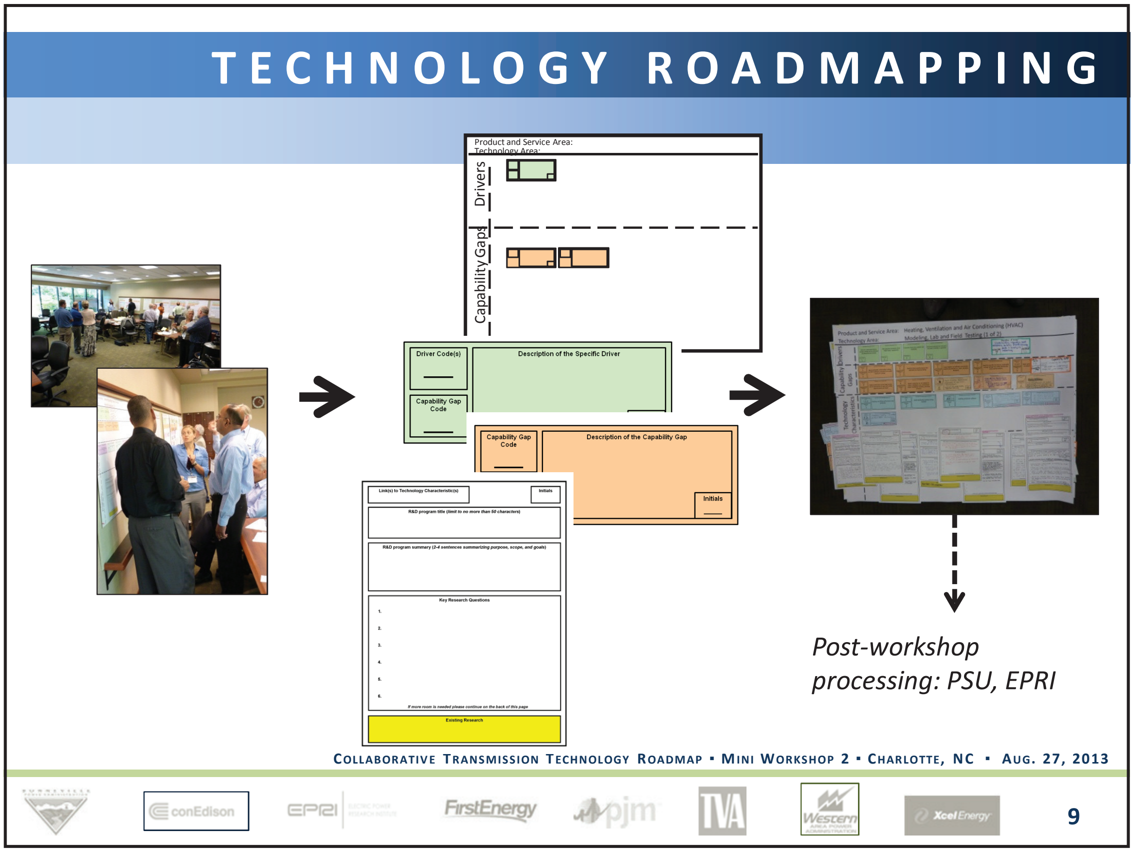
Values to Organization

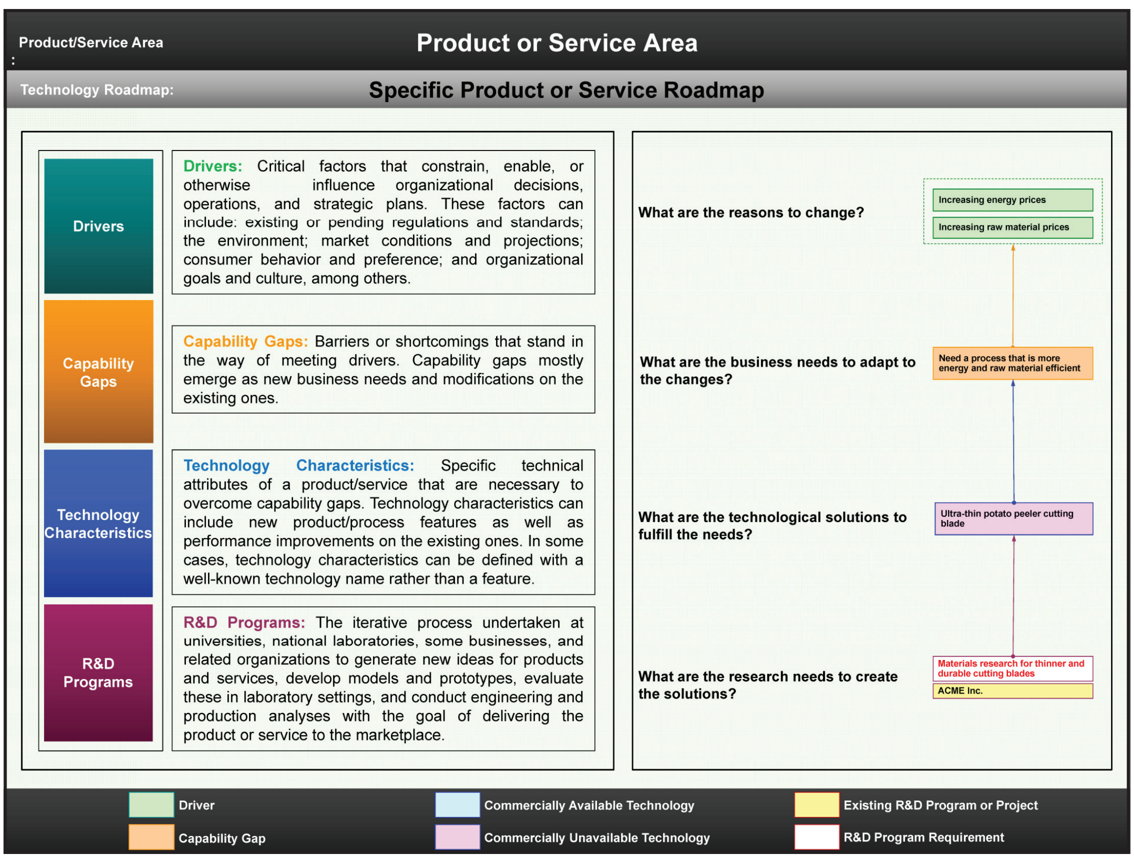
- Aligning organizational priorities with R&D planning and investment.
  - BPA Technology Innovation Office's annual solicitation.
- Fostering increased communication and collaboration within and beyond an organization.
  - EPRI's transmission technology roadmaps
  - Collaborative Transmission Technology Roadmap Pilot Project

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*.
- U.N. cites 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





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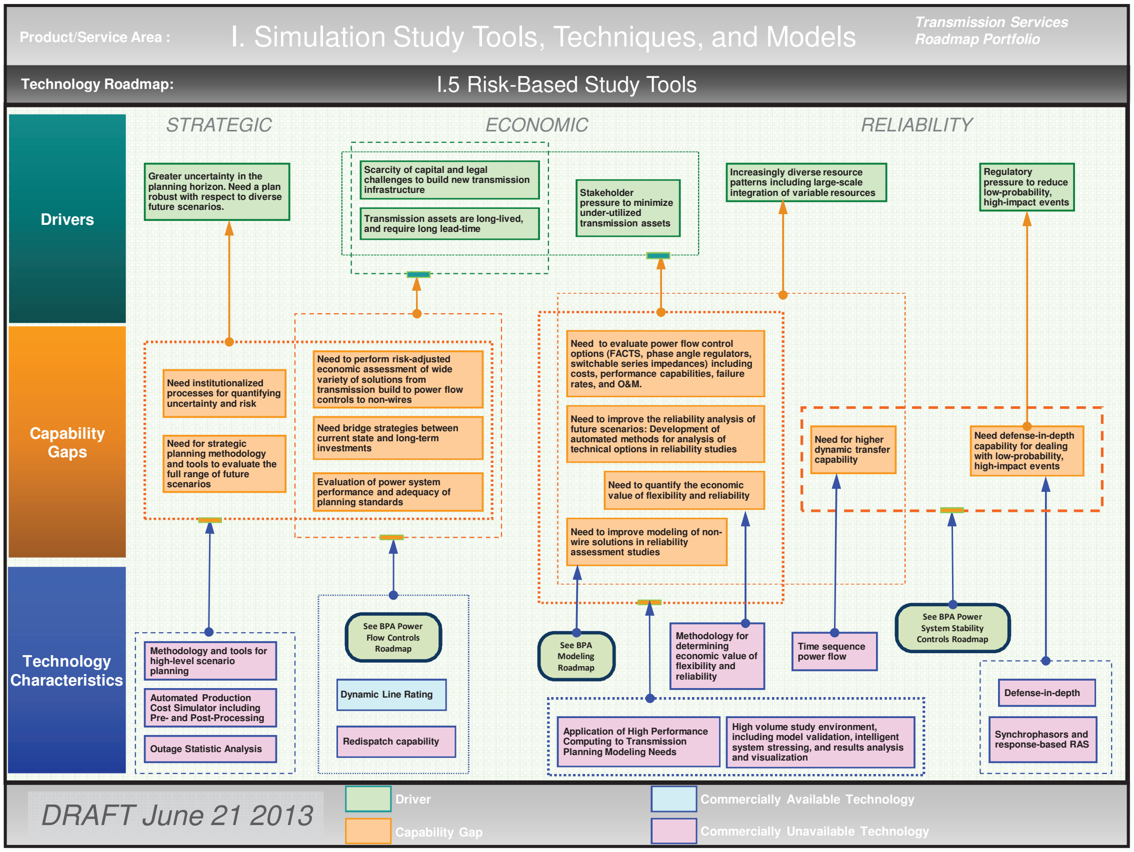
Product/Service Area :
I. Simulation Study Tools, Techniques, and Models
Transmission Services Roadmap Portfolio
Technology Roadmap:
I.5 Risk-Based Study Tools
STRATEGIC
ECONOMIC
RELIABILITY
Drivers
Capability Gaps
Technology Characteristics
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Methodology and tools for high-level scenario planning
Automated Production Cost Simulator including Pre- and Post-Processing
Outage Statistic Analysis
See BPA Power Flow Controls Roadmap
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Redispatch capability
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Methodology for determining economic value of flexibility and reliability
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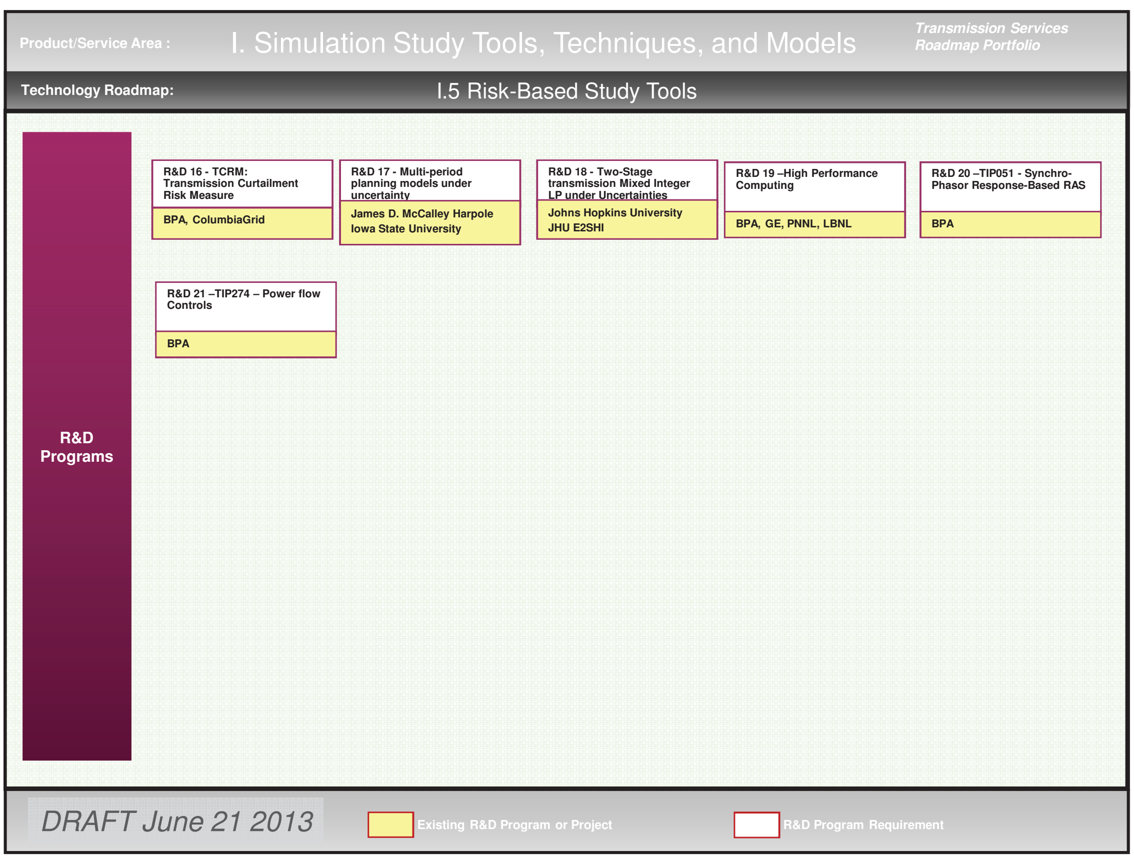
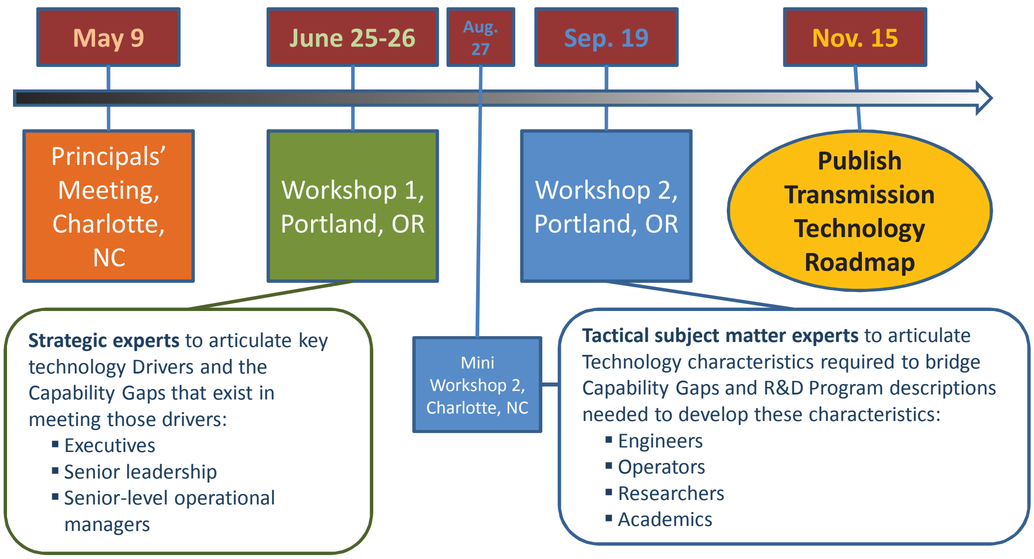
Application of High Performance Computing to Transmission Planning Modeling Needs
High volume study environment, including model validation, intelligent system stressing, and results analysis and visualization
Defense-in-depth
Synchrophasors and response-based RAS
DRAFT June 21 2013
Driver
Capability Gap
Commercially Available Technology
Commercially Unavailable Technology


Product/Service Area :
I. Simulation Study Tools, Techniques, and Models
Transmission Services Roadmap Portfolio
Technology Roadmap:
I.5 Risk-Based Study Tools
R&D Programs
R&D 16 - TCRM: Transmission Curtailment Risk Measure
BPA, ColumbiaGrid
R&D 17 - Multi-period planning models under uncertainty
James D. McCalley Harpole
Iowa State University
R&D 18 - Two-Stage transmission Mixed Integer LP under Uncertainties
Johns Hopkins University
JHU E2SHI
R&D 19 –High Performance Computing
BPA, GE, PNNL, LBNL
R&D 20 –TIP051 - Synchro-Phasor Response-Based RAS
BPA
R&D 21 –TIP274 – Power flow Controls
BPA
DRAFT June 21 2013
Existing R&D Program or Project
R&D Program Requirement

Project Tasks, Schedule, & Deliverables



Project Tasks, Schedule, & Deliverables

Workshop 1

Objective: Identify strategic Drivers and Capability Gaps for the high-priority Technology Areas selected at the Principals' meeting of May 9, 2013.

Tentative Schedule: Two-day workshop in Portland, Oregon, June 25–26, 2013.

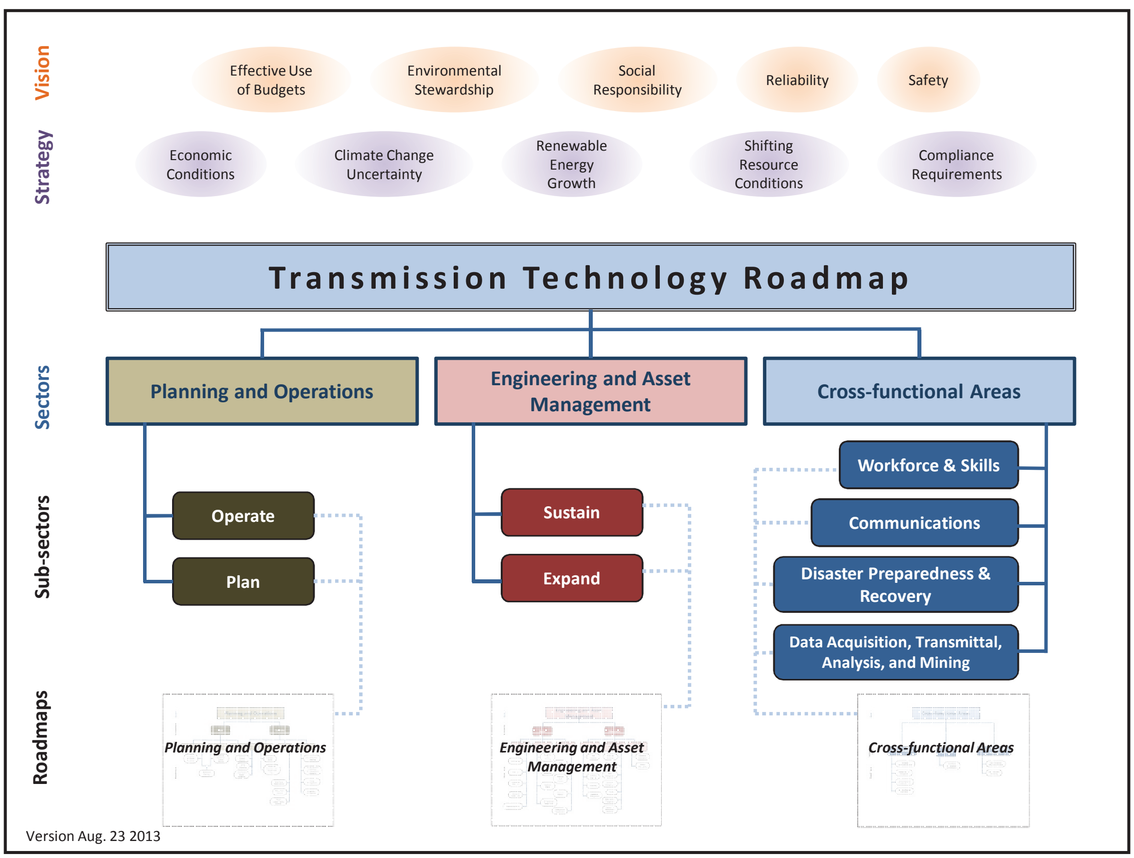
Participants Sought from Collaborating Organizations: Senior-level leaders and operations managers involved in developing and/or implementing corporate strategy (including public policy, regulatory compliance, business development, etc.), as well as having familiarity with the role played by transmission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

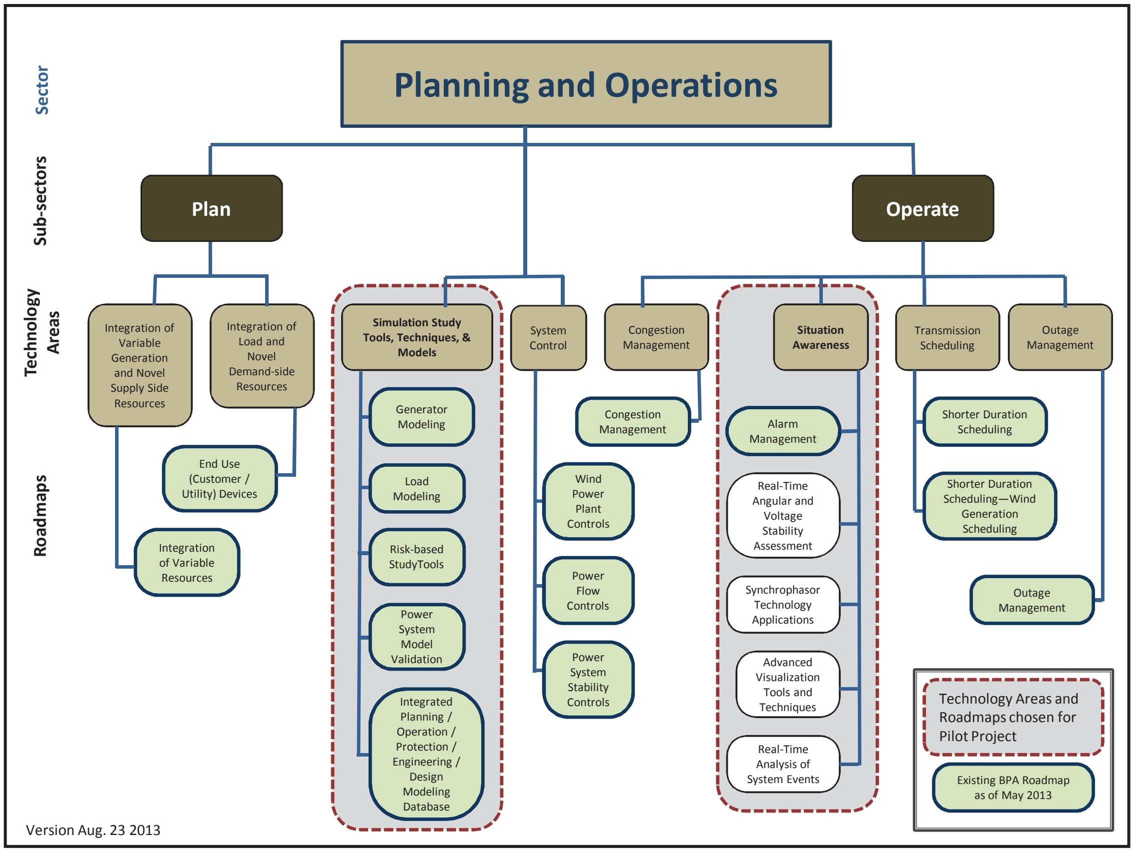
Workshop 2

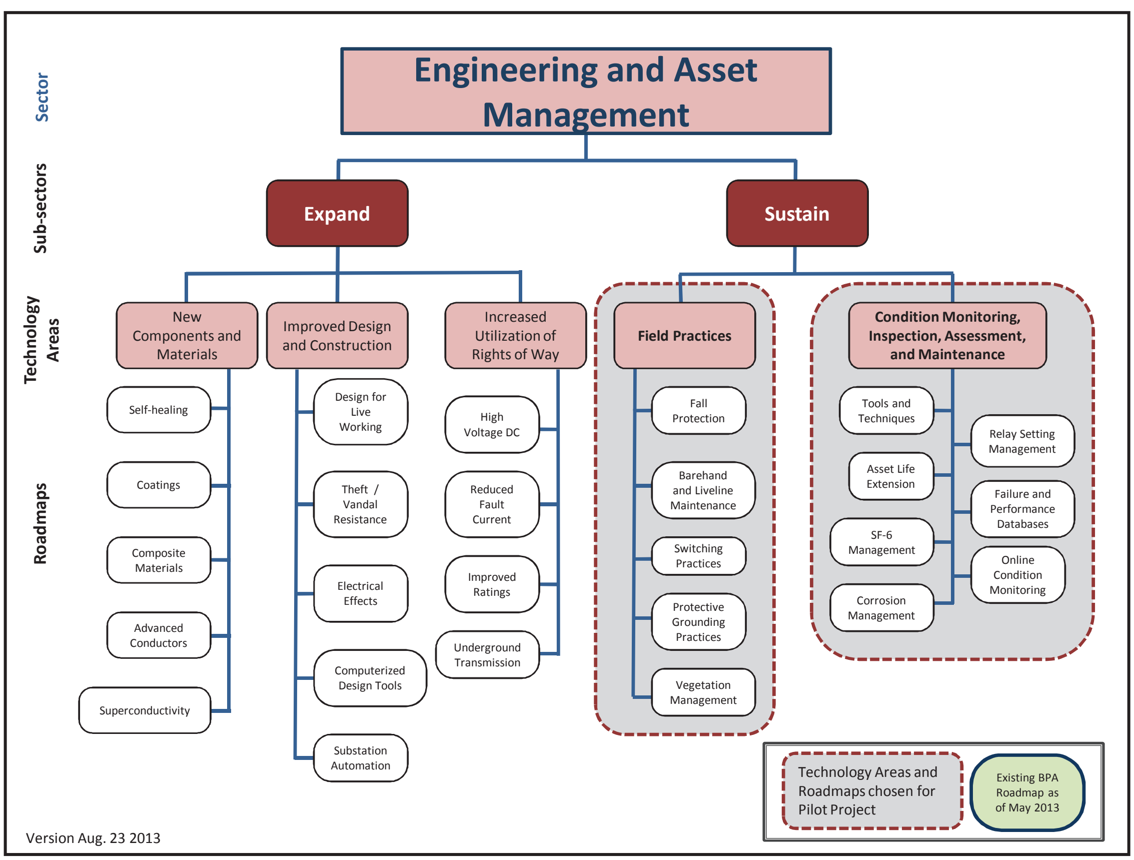
Objective: Within the Technology Areas selected at the Principals' Meeting, identify the Technology Characteristics and R&D Programs that address strategic Drivers and Capability Gaps identified during Workshop 1.

Tentative Schedule: 1-day workshop in Portland, Oregon, September 19.

Participants Sought from Collaborating Organizations, National Laboratories, Universities, R&D Organizations, and Vendors: Subject matter experts (SMEs) from throughout North America to develop the "tactical" content of the roadmaps—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 transmission technologies, models, algorithms, systems, etc.







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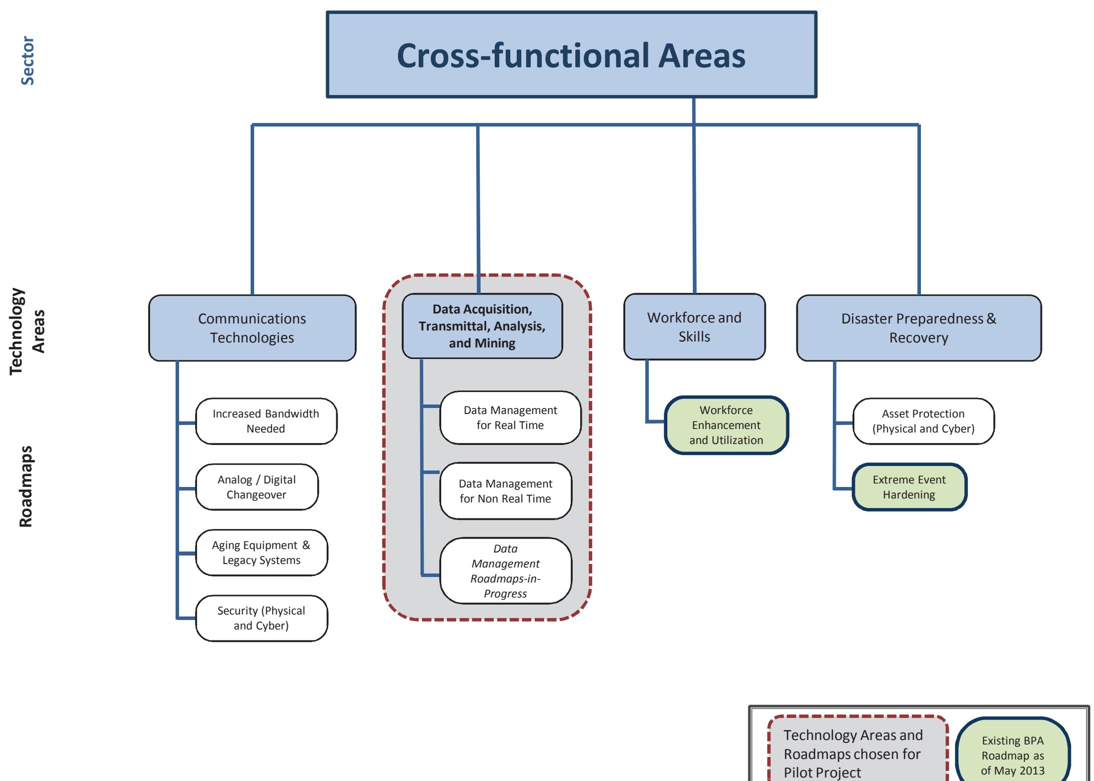

Version Aug. 23 2013

Team Assignments

NEXT STEPS

- PSU team will transcribe and process Mini Workshop 2 output and prepare for Workshop 2 (Sep. 18-19).
- Convene practitioners, subject matter experts, and R&D community for Workshop 2 in Portland, OR, Sep. 19, 2013.

CLOSING

Thank you for participating!

Contact Info:

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(614) 764-0920
nbhatt@epri.com

Bob Entriken
(650) 855-2198
rentriken@epri.com

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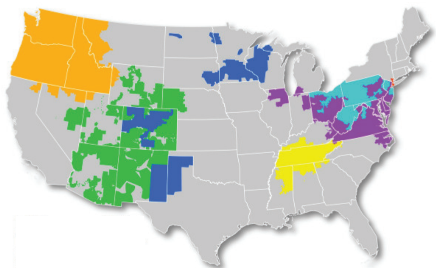
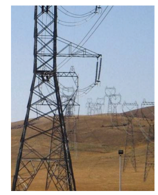
Collaborative Transmission Technology Roadmap

Workshop 2: Technology Characteristics and R&D Programs

Portland, OR ▪ Sep. 18-19, 2013


Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy ▪ PJM Interconnection ▪ Tennessee Valley authority ▪ Western Area Power Administration ▪ Xcel Energy

WELCOME

Thank you for coming!

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WELCOME

Daniel Brooks - EPRI

WELCOME

Larry Bekkedahl – BPA Sr. Vice President of Transmission

Terry Oliver – BPA Chief Technology Officer

WELCOME

INTRODUCTIONS

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.
  - EPRI's transmission technology roadmaps
  - Collaborative Transmission Technology Roadmap Pilot Project

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TECHNOLOGY ROADMAPPING

How?

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.

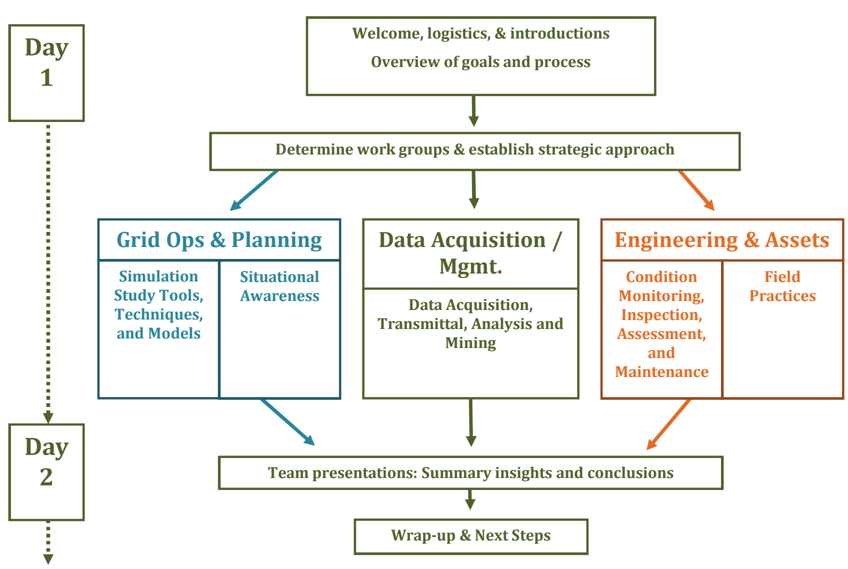
AGENDA: DAY 1

8:00 a.m.	**Welcome, logistics, & introductions** **Overview of workshop objectives** **Overview of roadmapping process**	Larry Bekkedahl, BPA Terry Oliver, BPA Daniel Brooks, EPRI Jeff Hildreth, BPA James Hillegas-Elting, BPA Tugrul U Daim, PSU
Objective 1	**Develop consensus on teams and approach**	
9:30 a.m.	**Review draft roadmap structure** **Determine teams & establish strategic approach**	Workshop Participants
10:00 a.m.	***BREAK***	
Objective 2	**Review, revise, and identify Technology Characteristics and R&D Programs**	
10:15 a.m.	**Identify Technology Characteristics linked to Capability Gaps** **Focus Question:** What are the core characteristics of a piece of equipment, a tool, an algorithm, a software program, 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
11:30 a.m.	***WORKING LUNCH**: Review activities / results from morning session*	
12:00 p.m.	**Continue Objective 2**	Workshop Participants
4:30 p.m.	**Conclude Day 1 and prepare for Day 2**	Jeff Hildreth, BPA
5:00 p.m.	**Adjourn**	

AGENDA: DAY 2

8:00 a.m.	Welcome & Check-in	Jeff Hildreth, BPA
8:30 a.m.	Prepare for team presentations: Review of Day 1 output	
9:30 a.m.	*BREAK*	
Objective 3	**Team presentations: Summary insights and conclusions**	
9:45 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 a.m.	***WORKING LUNCH**: Continue team presentations & group discussion*	
	Continue Objective 3	Workshop Participants
11:45 a.m.	Wrap-up & next steps	Jeff Hildreth, BPA
12:00 p.m.	Adjourn	

AGENDA: SCHEMATIC



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Roadmapping at BPA & EPRI

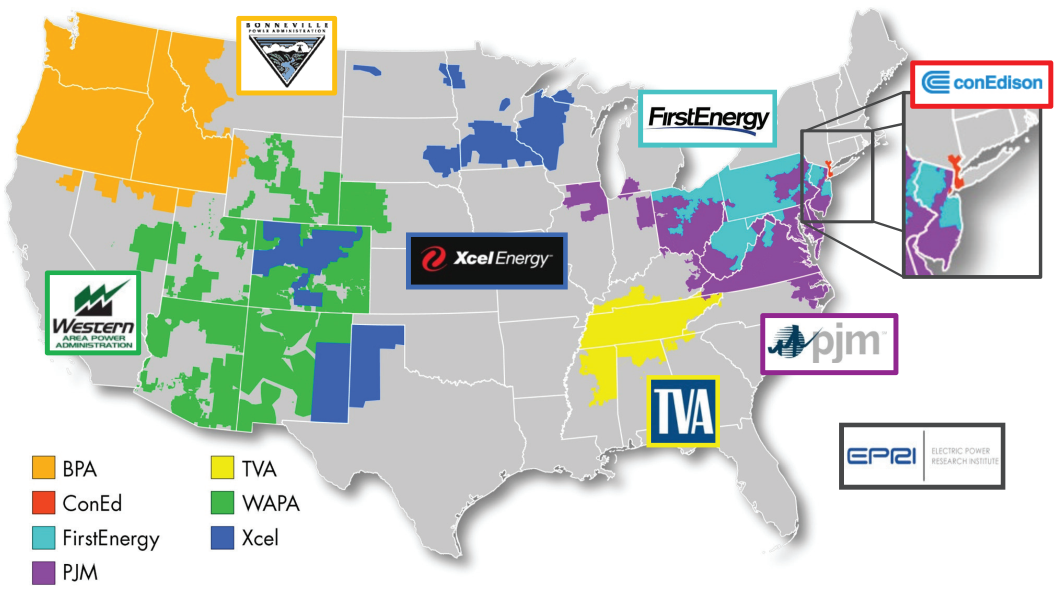
Technology Roadmapping

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*.
- U.N. cites 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

Service Territories



Project Tasks, Schedule, & Deliverables

May 9 — Principals' Meeting, Charlotte, NC

June 25-26 — Workshop 1, Portland, OR

Aug. 27 — Mini Workshop 2, Charlotte, NC

Sep. 18-19 — Workshop 2, Portland, OR

Nov. 15 — **Publish Transmission Technology Roadmap**

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

- Executives
- Senior leadership
- Senior-level operational managers

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

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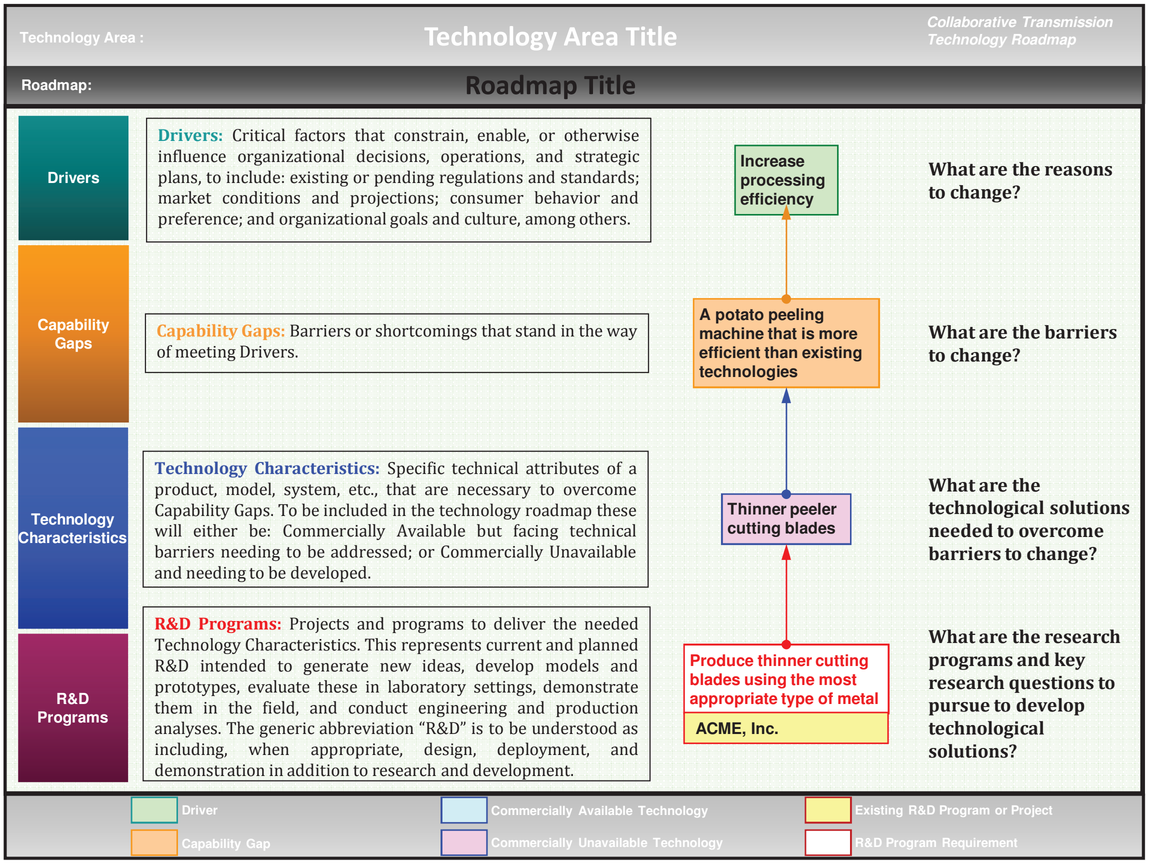
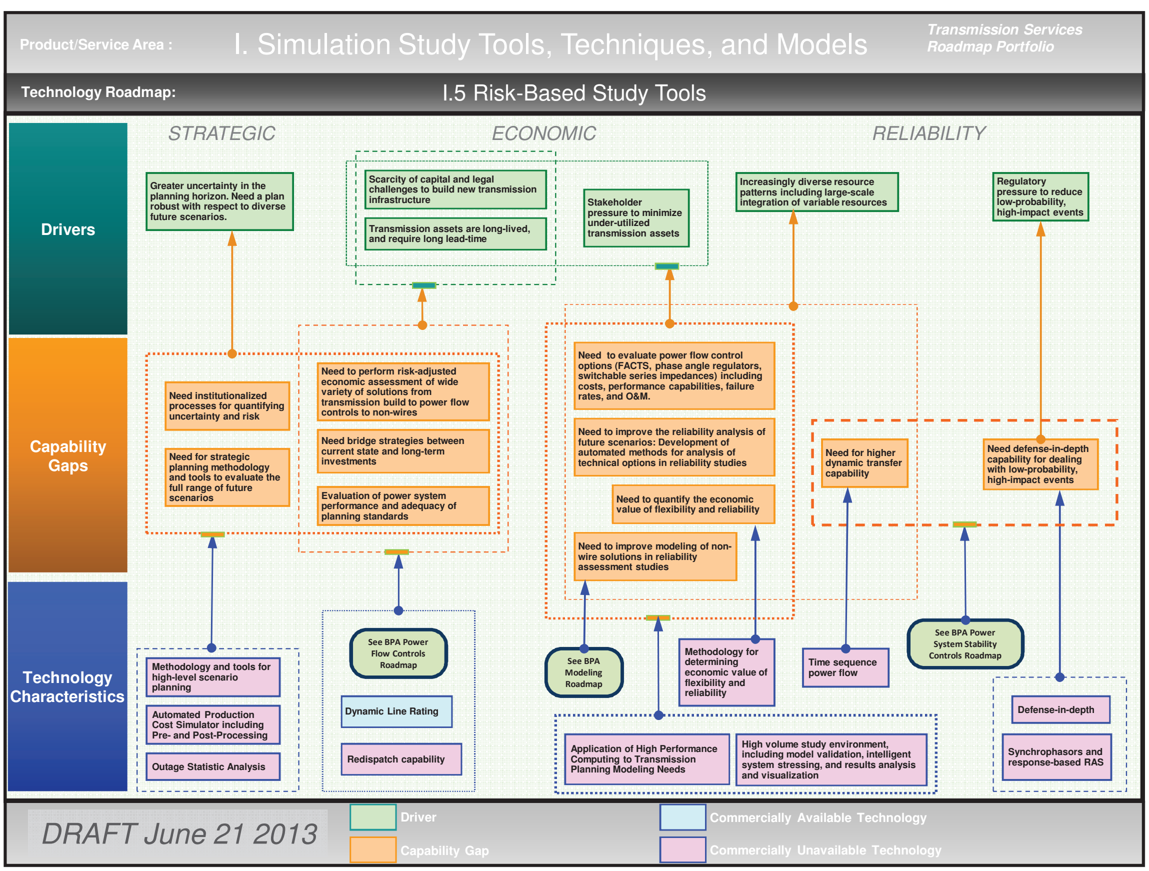

Technology Area :
Technology Area Title
Collaborative Transmission Technology Roadmap
Roadmap:
Roadmap Title
Drivers
Capability Gaps
Technology Characteristics
R&D Programs
Drivers: Critical factors that constrain, enable, or otherwise influence organizational decisions, operations, and strategic plans, to include: existing or pending regulations and standards; market conditions and projections; consumer behavior and preference; and organizational goals and culture, among others.
Capability Gaps: Barriers or shortcomings that stand in the way of meeting Drivers.
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.
R&D Programs: Projects and programs to deliver the needed Technology Characteristics. This represents current and planned R&D intended to generate new ideas, develop models and prototypes, evaluate these in laboratory settings, demonstrate them in the field, and conduct engineering and production analyses. The generic abbreviation "R&D" is to be understood as including, when appropriate, design, deployment, and demonstration in addition to research and development.
Increase processing efficiency
A potato peeling machine that is more efficient than existing technologies
Thinner peeler cutting blades
Produce thinner cutting blades using the most appropriate type of metal
ACME, Inc.
What are the reasons to change?
What are the barriers to change?
What are the technological solutions needed to overcome barriers to change?
What are the research programs and key research questions to pursue to develop technological solutions?
Driver
Capability Gap
Commercially Available Technology
Commercially Unavailable Technology
Existing R&D Program or Project
R&D Program Requirement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DRAFT June 21 2013
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Capability Gap
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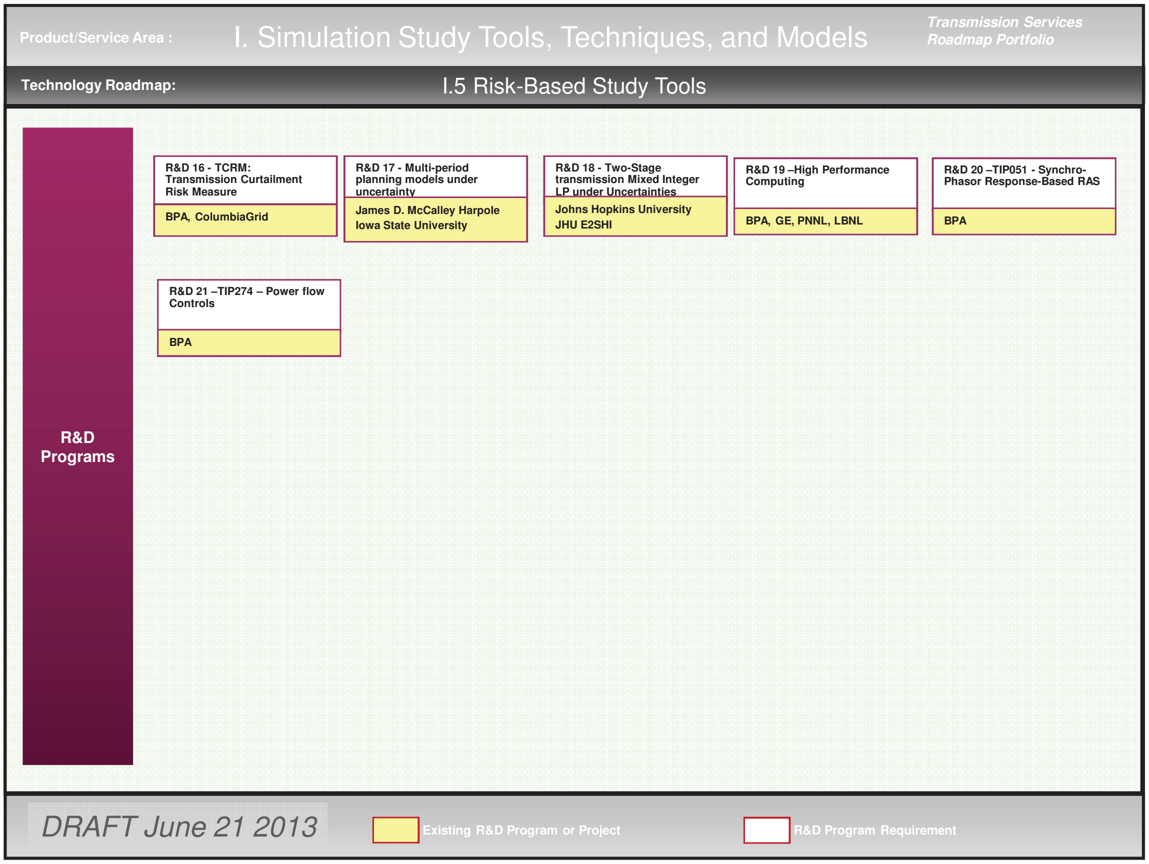

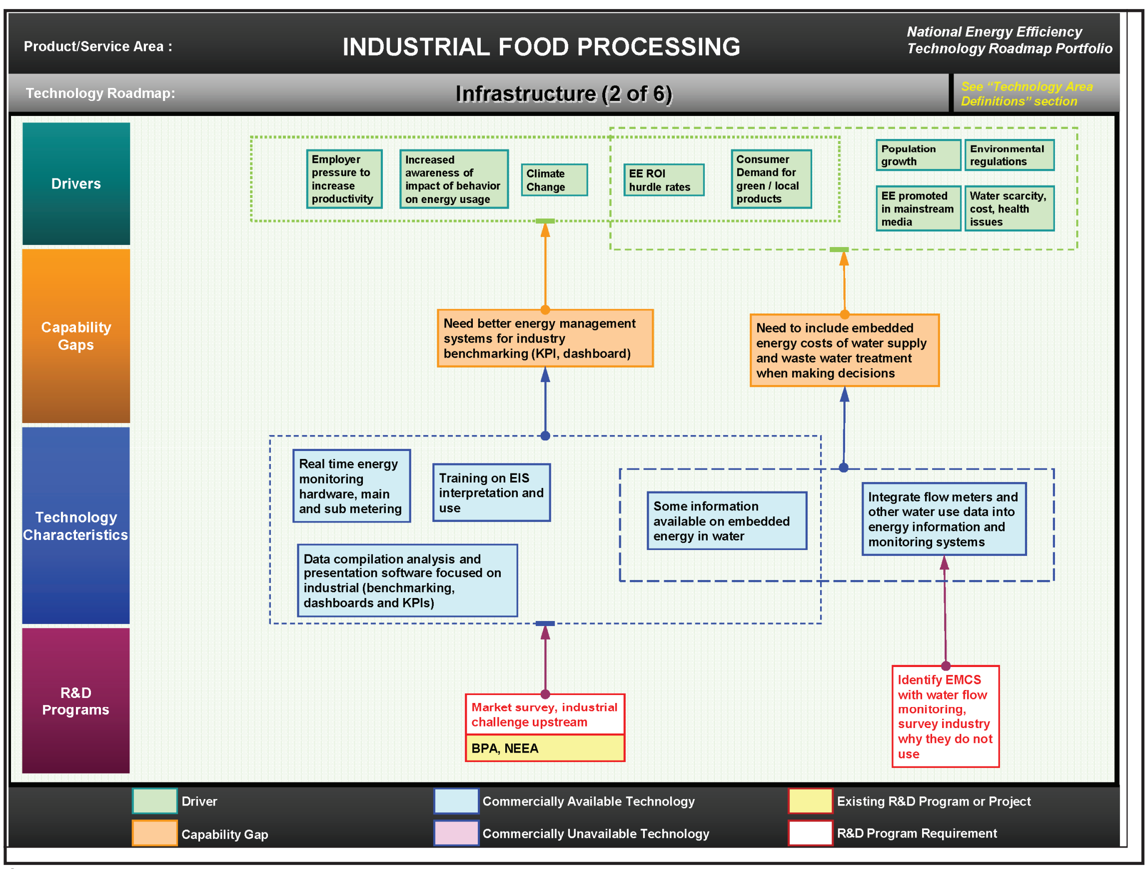

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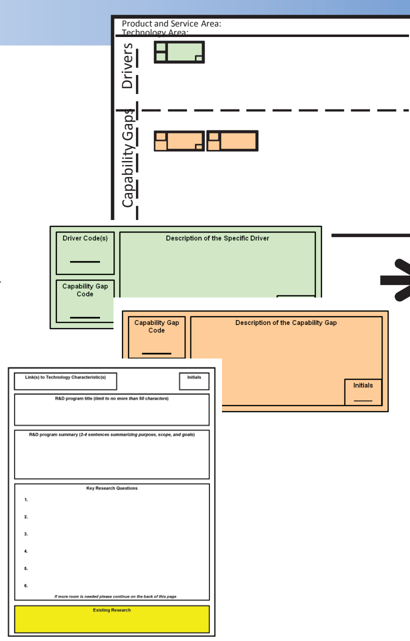
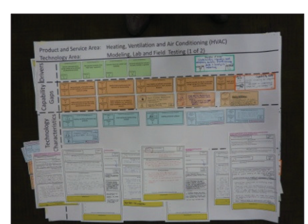
OBJECTIVES

Build upon the output of Workshop 1 to:

1) Link Technology Characteristics with identified Capability Gaps, and
2) Articulate R&D program descriptions and key research questions to develop the linked Technology Characteristics.

TECHNOLOGY ROADMAPPING





Post-workshop processing: PSU, EPRI

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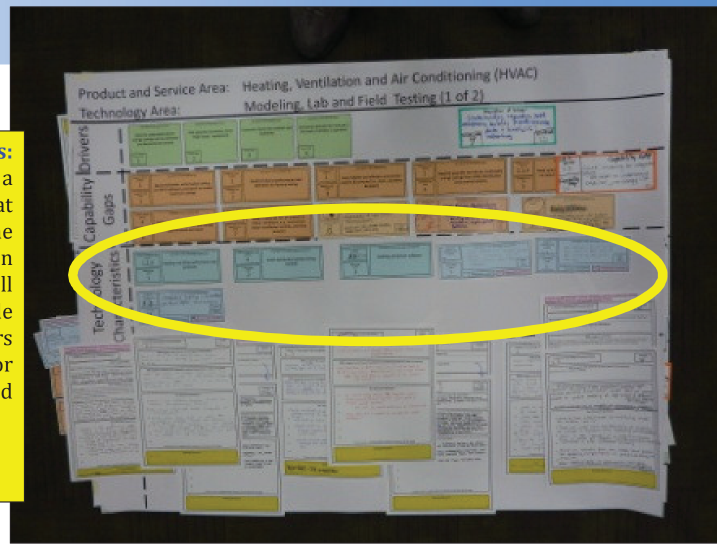

1. Review the current technology characteristics and verify that they address the gap identified
2. Review all capability gaps w/o any technology ch linked and propose technology ch

Review Existing R&D Program Cards

Product and Service Area: Data Acquisition, Transmittal, Analysis and Mining
Roadmap Area: Data management for Non-Real Time

Link(s) to Technology Characteristic(s) | Initials

R&D program title

July 2013: Data Mining to Characterize Signatures of Impending System Events or Performance from PMU Measurements (S-44)

Suggested revision (*limit to no more than 50 characters*):

July 2013: This project applies data minin[g] ... performance from PMU measurements. The ... these tools to characterize signatures of imp[...] measurements from multiple locations will a[...] verified by comparing the results obtained fo[...]

Suggested revision (*2-4 sentences* ...

1. How can data mining techniqu[es] ... events or performance from P[MU] ...
2. What is the performance of the ... events on the system?
3.
4.
5.

If more room is ne[eded] ...

University of Wisconsin - PESERC

Product and Service Area: Simulation Study Tools, Techniques, and Models
Roadmap Area: Risk-Based Study Tools

Link(s) to Technology Characteristic(s) | Initials

R&D program title

July 2013: TIP274 – Power flow Controls

Suggested revision (*limit to no more than 50 characters*):

R&D program summary

Provide 2-4 sentences summarizing purpose, scope, and goals

Key Research Questions

1.
2.
3.
4.
5.

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

Existing Research

BPA

- ✓ Check each program for relevancy (Do the R&D cards relate to any technology characteristics in the roadmap?)
  - No, mark the whole page with an "x" and keep them aside for disposal
- ✓ Review the existing content and consider suggesting revisions if required
  - R&D program title
  - R&D program summary
  - Key research questions
  - Existing research
- ✓ Provide the initials of the idea owner
- ✓ Provide the linkages to technology characteristics
- ✓ Tape the R&D card on the relevant poster

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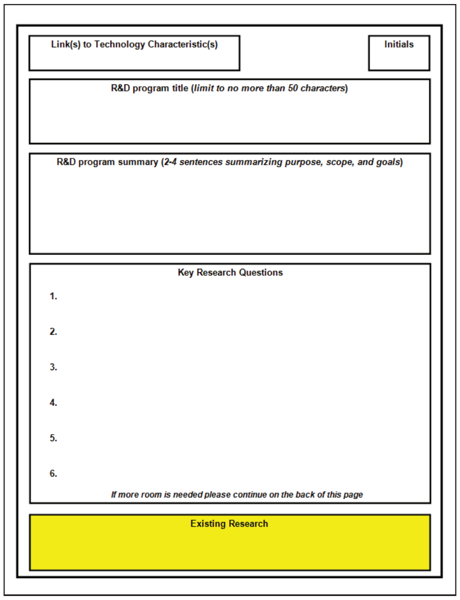
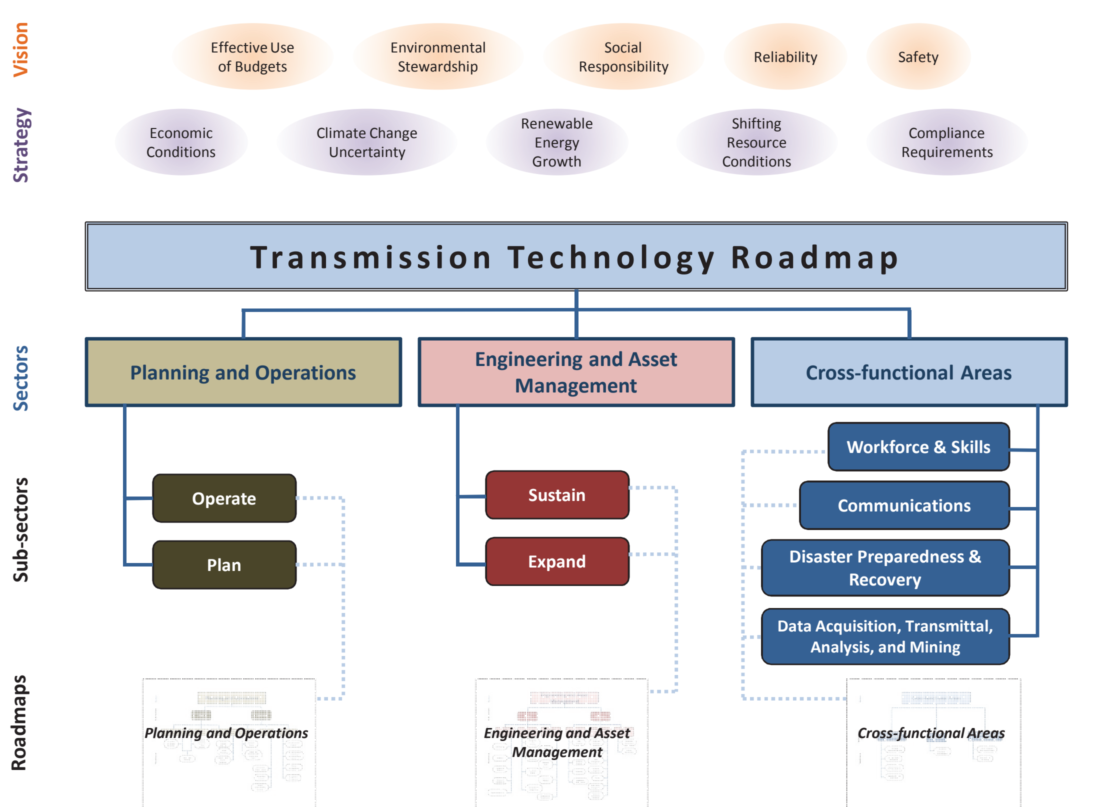
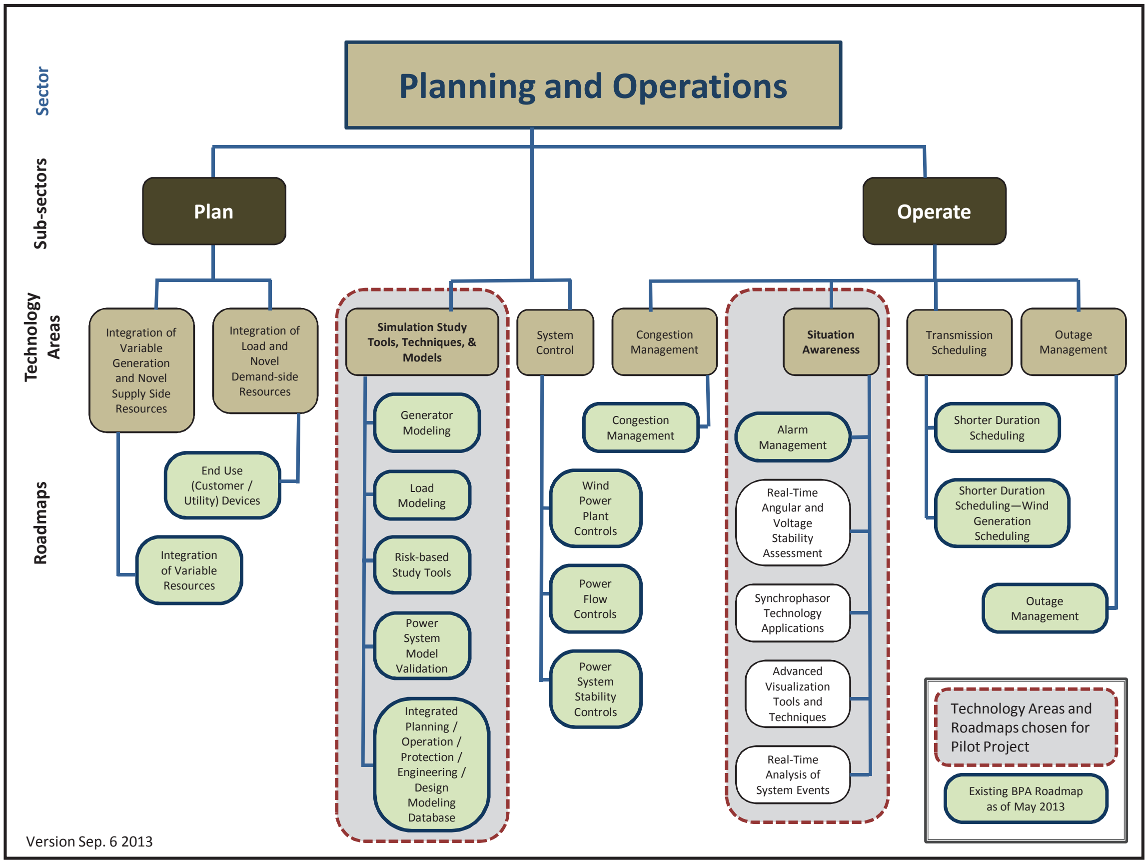
Propose New R&D Programs

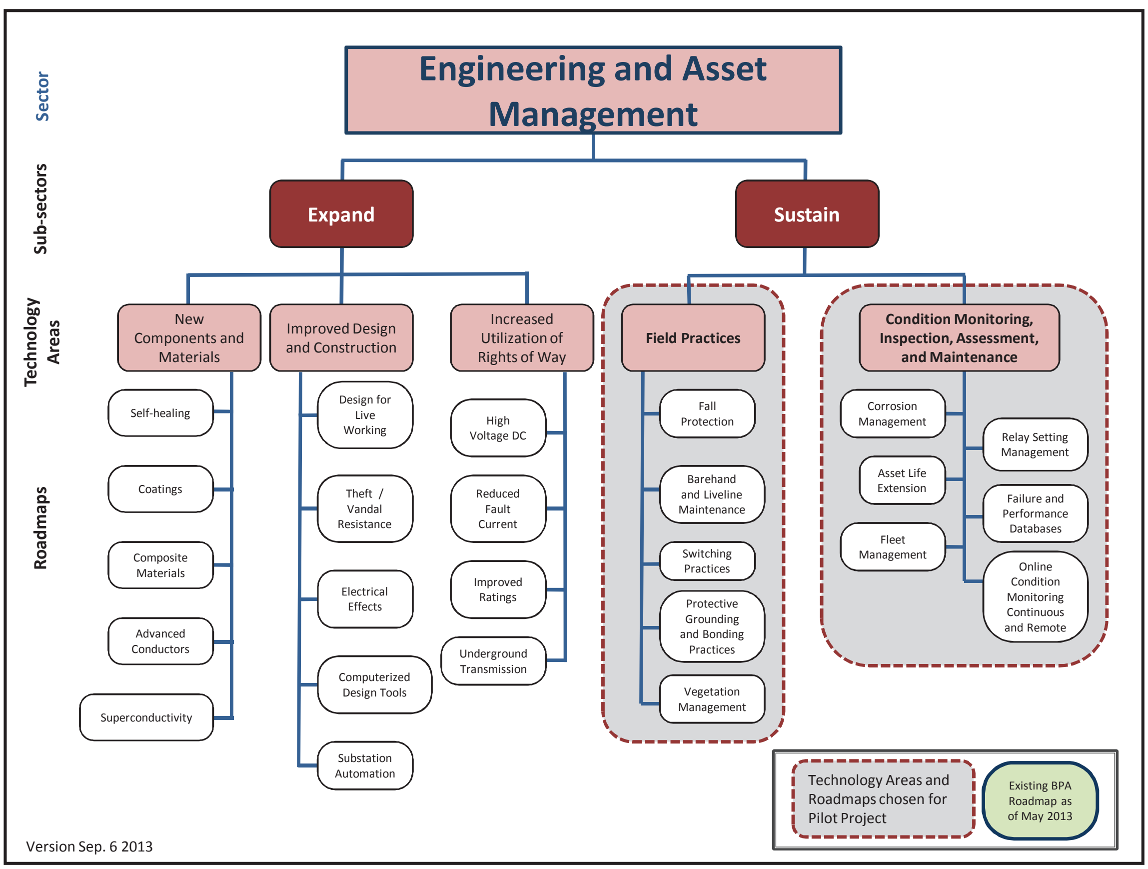

Link(s) to Technology Characteristic(s)
Initials
R&D program title (*limit to no more than 50 characters*)
R&D program summary (*2-4 sentences summarizing purpose, scope, and goals*)
Key Research Questions
1.
2.
3.
4.
5.
6.
If more room is needed please continue on the back of this page
Existing Research

- ✓ Check each technology characteristic for R&D program requirements (Are the technology characteristics addressed by the existing R&D cards?)
  - Yes, no need for new R&D cards
- ✓ Use plain cards (white) for proposing new R&D cards
- ✓ Provide content for the following spaces
  - R&D program title
  - R&D program summary
  - Key research questions
  - Existing research
- ✓ Provide the initials of the idea owner
- ✓ Provide the linkages to technology characteristics
- ✓ Tape the R&D card on the relevant poster



Version Sep. 6 2013





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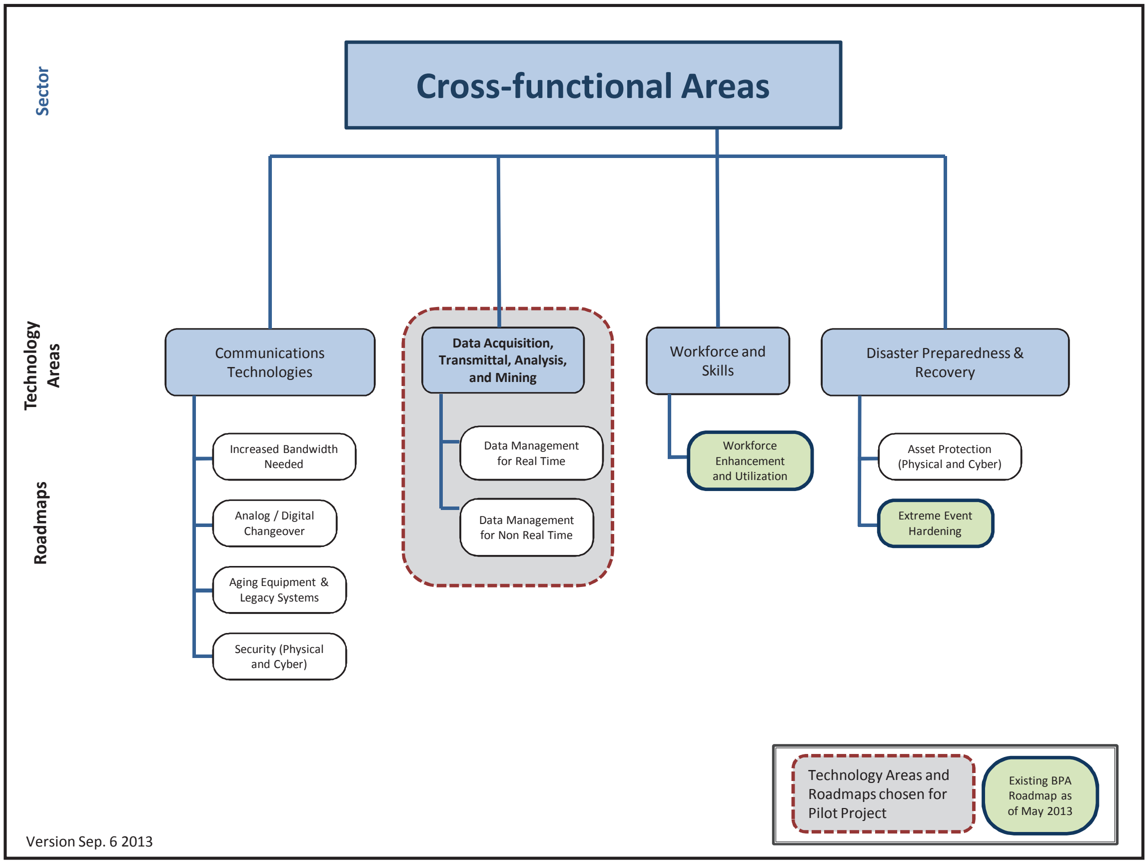

Team Assignments

ST – Simulation Study Tools, Techniques, and Models

SA – Situational Awareness

CM – Condition Monitoring, Inspection, Assessment, and Maintenance

FP – Field Practices

DA – Data Acquisition, Transmittal, Analysis, and Mining

NEXT STEPS

- Roadmap team (including BPA, PSU, and EPRI) will transcribe and process Workshop 2 output and prepare the draft roadmap between Sep. 20 and Oct. 31.
  - *Workshop 2 participants invited to provide post-workshop follow-up or clarifying information*
- Draft roadmap will be made available to all contributors in early Nov. for feedback and comment.
- Document will be refined and published by November 15.
- Roadmap to be to be published on the BPA website and reviewed by utility partners in Dec.

CLOSING

Thank you for participating!

Contact Info:

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nbhatt@epri.com

Bob Entriken
(650) 855-2198
rentriken@epri.com

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Collaborative Transmission Technology Roadmap Pilot

Workshop 2 ~ September 18–19, 2013

Team presentations: Summary Insights and Conclusions

Attendees

Condition Monitoring, Inspection, Assessment and Maintenance

- Richard Becker, Jr., Bonneville Power Administration
- Fabio Bologna, Electric Power Research Institute
- Jason Burt, Bonneville Power Administration
- Terence Carr, Xcel Energy Services, Inc.
- Bhavin Desai, Electric Power Research Institute
- Nick Dominelli, Powertech Labs., Inc.
- Ivo Hug, Electric Power Research Institute
- Hong Li, Powertech Labs., Inc.
- Mike Miller, Bonneville Power Administration
- Martin Monnig, Bonneville Power Administration
- Arturo Nunez, MISTRAS Group, Inc.
- Andrew Phillips, Electric Power Research Institute
- Tim Shaw, Electric Power Research Institute
- Luke Van der Zel, Electric Power Research Institute

Data Acquisition / Transmittal / Analysis / Mining

- Robert Bass, Portland State University
- Anjan Bose, Washington State University
- Richard Bravo, Southern California Edison Company
- Eduardo Cotilla-Sanchez, Oregon State University
- Jeff Dagle, Pacific Northwest National Laboratory
- Tony Faris, Bonneville Power Administration
- Tiffany Gibby, Tennessee Valley Authority
- Jay Giri, ALSTOM Grid
- John Grosh, Lawrence Livermore National Laboratory
- Walt Johnson, Electric Power Research Institute
- Yilu Liu, University of Tennessee
- Michelle Odajima, Xcel Energy Services, Inc.
- Subhash Paluru, Western Area Power Administration
- Brad Wagner, Xcel Energy Services, Inc.

Field Practices

- Kevin Howard, Western Area Power Administration
- Sara Madugula, Tennessee Valley Authority
- Loui McCurley, Pigeon Mountain Industries
- Ron Rowe, Bonneville Power Administration
- Michael Staats, Bonneville Power Administration

Situation Awareness

- James Anderson, Bonneville Power Administration
- Robert Austin, First Energy Corporation
- Aranya Chakrabortty, North Carolina State University
- Albert Choi, Xcel Energy Services, Inc.
- Erik Connors, SA Technologies
- DeJim Lowe, Tennessee Valley Authority
- Jodi Obradovich, Battelle Pacific Northwest Laboratories
- Ryan Quint, Bonneville Power Administration
- Kai Sun University, of Tennessee
- Mark Tiemeier, Xcel Energy Services, Inc.
- Marianna Vaiman, V&R Company, Energy System Research
- Kumar Venayagamoorthy, Clemson University
- Donald Watkins, Bonneville Power Administration

Simulation Study Tools, Techniques and Models

- Mike Agudo, Western Area Power Administration
- Philip Augustin, Portland General Electric Company
- Gil Bindewald, U.S. Dept. of Energy
- Daniel Brooks, Electric Power Research Institute
- Jay Caspary, Southwest Power Pool, Inc.
- Juan Castaneda, Southern California Edison Company
- Dave Cathcart, Bonneville Power Administration
- Joe Chow, Rensselaer Polytechnic Institute
- Kara Clark, National Renewable Energy Laboratory
- Aleksandar Dimitrovski, Oak Ridge National Laboratory
- Sean Erickson, Western Area Power Administration
- Jason Espeseth, Xcel Energy Services, Inc.
- Fred Huang, Electric Reliability Council of Texas
- Anders Johnson, Bonneville Power Administration
- Dmitry Kosterev, Bonneville Power Administration
- Ben Kujala, Northwest Power & Conservation Council
- Xiaodong Liang, Washington State University
- Shuai Lu, Pacific Northwest National Lab.
- Jim McCalley, Iowa State University
- Liang Min, Lawrence Livermore National Laboratory
- Bernard O'Hara, PJM Interconnection
- Robin Podmore, Incremental Systems
- Sandip Sharma, Electric Reliability Council of Texas
- Kevin Tomsovic, University of Tennessee
- Steve Yang, Bonneville Power Administration

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Collaborative Transmission Technology Roadmap Pilot

Workshop 2 ~ September 18–19, 2013

Team presentations: Summary Insights and Conclusions

Agenda

- Situation Awareness
- Condition Monitoring
- Field Practices
- Study Tools
- Data Analysis

Situation Awareness

[Don Watkins] Synchrophasors. The key point is to obtain situation awareness and intelligence for predictive means. As you get a real-time data stream going, you can use it for other things. For instance, PMUs can inform state estimators, as a basis for getting good information out.

Data mining is really important. As data streams through a utility communication system, it has to be transformed into information. It needs to be mined to deal with long-term issues. For instance, a geographic distribution of measurements can help to detect electrical islands.

While a situation may seem simple after an event, the real-time information does not necessarily indicate that an event is in progress. Tools need to conduct event detection and determine how to share the relevant data and information. There should be redundancy for any distributed computing capability. We also need real-time models.

[Marianna Vaiman] Real Time Angle and Stability Assessment. This roadmap overlaps with other roadmapping activities. The prerequisite is having a reliable network and database models. The electricity industry needs enhanced state estimation, without fictitious pseudo loads. It needs PMU-based linear state estimation. There is research to partially cover this, but there is also a wide need for further enhancements.

A hybrid data state estimator can be created.

PMU-based stability analysis is possible. The alarms will be addressed separately. Combined angle-based stability limits with RT RAS modeling and determining stability limits in real time can help identify margins and boundaries. We need also to separate numerical computing issues from collapse/boundary conditions.

All the tools are only as good as their effectiveness in use. Training is needed to ensure their effective use.

[Kai Sun] Real Time and Predictive Event Analysis. The predictive element is purposefully added, which was not there prior. It allows operators to increase their ability to know the accurate system capability.

There are six drivers, but the highlights are to know accurately the ATC and the multi-contingency events and coordination between operators, per regulations. The SE models should cover also neighboring systems. How can you see below 100kV?

Four categories are: Analysis (the transform from data to information to knowledge), sharing information for big-picture view, sharing models of network and equipment, forecasting to know stress in the system, how to do mitigation.

[Erik Connors] Advanced Visualization Tools. Need to get information in front of the right audience. How can we visualize wide-area concerns? How can we deal with data overload? There is a lack of human factors guidelines that can help to communicate better the wide-area situation across multiple organizations.

Predictive tools can help get ahead of real time.

The roadmap addresses needs as a user-centric exercise. This RM is difficult to separate from analysis, but how to predict is a factor [TBD meaning?]. The focus should be on the decision making of the operator, engineer, or marketing. Having a common view will help the industry move forward together.

- Roadmap strongly tied to real-time and predictive analysis of system events represents the front end.

- Emphasis is on the lack of appropriate visuals to support current operations along with new concerns, such as intermittent resources, phasor data, wide area measurements.
- There are additional concerns about data overload, lack of human factors guidelines, how to present data appropriately and video wall levels, and predictive tools.
- Highlight: The roadmap addresses and emphasizes the need for advanced tool development beyond the current tech-centric and data-centric designs, toward a user-centric viewpoint.
- Low Light: It is hard to keep this roadmap separate from the RT / Predictive Analysis and the Alarm Management roadmaps.

[Bob Austin] Alarm Management. The initial alarm function may not have anticipated the wide use and audience of alarms. There is a long list of persons in the audience for alarm data; Operators, control room engineers, planning engineers, protection engineers, commissioning engineers, IT programmers, IT EMS monitoring engineers, communication engineers respond to electrical system disturbances and events with a sense of urgency. All require alarm data. Post event, back office, and real time staff such as network engineers, communication engineers, and settlement compliance require alarm information.

EMS alarms are an indication and record of system changes. It was not anticipated to have such a large audience. We need to rethink alarms from the control room perspective, but all of these other audiences are important too. The industry requires automated intelligence analysis to eliminate the overwhelming flow of information. There can be 60 indications among 10,000 alarms. They are not all related to the electrical system. The exercise of the group is based on an assumption of large quantities of information. Prompt, clear, and precise information is required.

[Mike (BPA, CM)] Did you address the "sharing" when subject to NERC CIP? [Erik Connors] We did talk about shared awareness. When there is sharing, the group can all interpret the information the same way. [DW] There are NDAs among operators. [MV] Neighboring coordination is being addressed, even shared topology.

[YL] What RT models are needed? [DW] The PMU data should be used in thoughtful ways. We look at wind generation models and compare them to what we need. We are interested in tools made from PMUs and in understanding the data in terms of system limits and thresholds. [Erik Connors] These will be basically state estimation models.

[Mike WAPA] Will PMU replace traditional state estimation? [DW] PMU measurements are data going into state estimation.

<u>Condition Monitoring</u>

[Bhavin Desai] This technical area focuses on sustaining and managing existing equipment. At the highest level is engineering and management, and below that is one of the critical parts of this job.

We started at the fundamental level to understand the failure modes and degradations. As a team, we had questions about how to use the information in order to help sustain existing assets. How do I repair replace refurbish, and monitor? We study many modes, and have lots of sensors, but we have to keep in mind the decisions that we are supporting. What is the guidance? What are the inspection tools and techniques? We have to create a holistic approach. The Technical Area has seven Roadmaps: Fleet management, online monitoring, detection and control, simple sensors, assessment with tools and techniques, industry-wide DB about failure and performance, and asset management metrics. [ed: Check against actual RM names]

You have infrastructure and you need to determine how to set up relays and get vendors to provide for needs. Corrosion management needs to be separately investigated. It is crosscutting and relates to above- and below-ground cables and device internals. These seven Roadmaps have the projects being integrated and aligned with gaps and drivers. The roadmaps are not yet robust.

[Ted Carr] There were six roadmaps at first, and we added one more. The seven RMs fit within Fleet Management, but we took them out because there too many specifics. During this meeting the team expanded further to one more.

There is existing research under all the RMs, which makes the RM exercise easier, but on life extension the top item is algorithms to take data and predict remaining life. There are models out there to support this. This helps to plan ahead, which has real value.

Corrosion Management affects above- and below-ground equipment, with aspects of material science and predicting future performance. One example is ground grids in substations.

Relay Settings. All manufacturers have various ways to access and set relays. There is not a common standard to help make this job easier, especially for coordinating various devices.

Failure and Performance Databases are the foundation to support the algorithms and case studies.

Online Condition Monitoring has many forms, like drone flights, attached sensors. Drones could look for hotspots with thermal sensors.

Inspections. Breakers, transformers, and other equipment come out of service for inspections. Can this be done live? Are there non-destructive techniques.

[Richard Becker] Some actions enable others. The system to collect and process data is an enabler. Standards and compatibility is enabling. Our technical area is dependent on others for future developments. We need systems in place to collect the data for the historical database about conducting inspections.

[Subhash] Can you share your experience and learning on a wiki? We will add that. [RB] Asset management has to answer what the critical data is for doing the job. Each vendor has a different solution, and using one choice may risk blind spots. Using multiple vendors risks incompatibilities.

[Jeff] Need to know failure modes. Monitor what? What sensors? etc. We will include in the roadmap the framework coming from the mini-workshop in Charlotte.

[Brad Wagner, Xcel] Is there R&D on the best algorithms? We are aware of research, but are not sure about the progress and results.

[Ivo Hug] I want to comment on the framework. It has to apply to each component, breakers, transformers, towers, …

<u>Field Practices</u>

[Kevin Howard] This Technical Area is concerned with safety, reliability, and cost reductions.

Fall Protection. The primary concern of this roadmap is safety. We want to avoid climbing. For instance, it can help to have an automated inspection by flight inspection or a robot that runs down wire. When climbing is expected, we should design the towers to support anchorages and design effective and easy to use personal protection equipment. We need materials that work well for harnesses, for arc flash, durability, and flexibility. Check out such materials, like insulated rope (hot rope). The industry needs work on rescue and training.

Bare Hand and Live Line Maintenance. Need to determine minimum approach distances. We would like to predict and model this parameter with a tool. We want to have a real time warning for minimum approach.

How can we test insulators prior to approaching live lines for work? Robotic tools were mentioned. The DA team (or other?) talked about the ability to test remotely. A tool might send a signal over a line to determine which structure has current leakage.

Utilities are inventing their own procedures and techniques for live-line work. We need a database for shared practices that can give information depending on the particular structures involved.

Protective Grounding and Bonding Practices. Need tools and modeling to understand hazards, like induced currents and ground voltage rise. For instance, a de-energized line can have induced currents from a parallel live line. This situation would be good to identify ahead of time. How can we measure this in the field? There is a technique close to commercialization, through a WAPA project. It can predict rises and produce an alarm.

A proximity voltage detector is useful. It is placed on a hot stick to make measures high above. Most times this device does not work in a live yard. It is sensitive to the wrong equipment.

We need a better single-point grounding technology for maintenance projects. Identify best practices and methods to determine the single-point grounding.

[Jim Anderson] Vegetation Management. Need a more cost-effective way to collect LIDAR data in a timely manner. Line crawlers and UAVs could help. We need improvements in analyzing the data for accuracy and making it timely. We sometimes take 6 months to get results, which is well within the time of a tree growing 15 feet.

Switching Practices. Can we have a tool that generates automatically needed switch-order sequences? It should know the RAS scheme. Can we train people to use such an automated tool and to conduct the exercise manually when necessary? Such a tool can help benchmark manual and automated methods.

[Jeff] This is very important. There were recently two fatalities in the Northwest. There was a fall and a lack of bonding.

[Ivo] Designs need to done for each ancillary function. Just like the example that a tower needs to be designed for climbing.

[Jeff] The electricity industry struggles get academia and the laboratories involved in this area.

Study Tools

[Phil Augustin, PGE] Study tools need good data. This is a starting assumption.

Power System Modeling. There are four existing programs from WECC.

[Bernie, PJM] Generator Modeling. The dispatch problem is changing. There are five existing research programs. We listed additional questions that we were not sure about being addressed. The wind predictor was not specifying the time frame.

A third item is BPA enhancement of dynamic models.

New programs are inter-area mode damping torque for stability and improved modeling of generators for economic dispatch (ramping and environmental impacts of ramping).

[Liang Xiaodong] Load Modeling. This is a most uncertain area, because of the complex interaction of load with the grid. How can we determine load composition (commercial, industrial, and residential)? This is needed for accurate modeling. How much influence do inverter (power electronic) loads have on grid reliability? There are measurement- and component-based models for load. How can we identify the critical parameters for load modeling under measurement methods? There are six existing and two new research programs.

[Liang Xiaodong] Integrated Database. How can you take all data to create a single baseline data set? There are examples of multiple groups having different line impedances. There may not yet exist an effort to pursue a comprehensive solution. EPRI, WECC, and Siemens are working on parts of one. There is an IEC effort on data coordination. We need a bigger more comprehensive effort.

There is a diagram on one of the posters depicting the flow of information and the boundaries of the scope of this effort.

[Ben Kujala] Risk Models. This is an extremely large area. There could be hundreds of research questions and technologies. It is a difficult subject to frame. There are many single-purpose models for this multi-purpose problem. There is a need for multi-purpose models or integration methods for the single purpose models. Technologies for high-performance computing and algorithm improvements can help speed up the calculations and make them more accurate. Improvements to Monte Carlo approaches can help. Parallelizing can help. Tail events are an area of focus, because they represent the outlying, non-normal conditions. The mean time before failure (MTBF) and other measures are indicative of deviations from normal conditions, but we need to understand the risks of extreme events.

There is a recent NW event of a double outage, which was rare. Coordination of hydro, gas, and weather is beginning to be important. Operators know that forecasts are imperfect, while dispatch uses deterministic decision-making techniques that do not necessarily hedge for uncertainties. How can we model the risk associated with changing policy decisions? How can we adapt regulation to a risk framework in order to improve efficiency and reliability? We also assume that the data is valid and accurate.

[Tiffany] Which standard? The IEC standard is 61968 (or 61908?).

[Aleks Dimitrovski] How do you define risk? [Ben] It is a measure of uncertainty. [Liang] Probability times impact. Minimizing the expected value may not be the right approach.

[Ivo] Are there clean, clear definitions available? [RE] It depends on the decision maker's appetite for risk.

[Kevin Howard] There is a nexus of fuel supply and electric supply; natural gas supply, deliverability, and availability. Did you look at gas-electric interactions? [BK] Yes, this leads back to the single-purpose models. There are many reasons for interactions with supply, including weather for VG and hydro. We need models to consider these properly for correlations and interdependencies.

<u>Data Analysis</u>

[Tiffany] We organized our comments according to highlights and hard spots. The hard spots were about getting organized. We moved the tables into a circle and got a facilitator to help move us along.

As users demand more information, and communication networks collect and transmit large quantities of data, the challenge remains to convert the data into useful information for utility decision makers. This technology area involves primary collection points, data consolidation, further transmittal to databases, and the analysis of large quantities of data.

Just about everything depends on data. Most of the topics in this workshop relate to data, whether they generate the data, use the data, or can be improved by data.[1]

There are two general classes of data that apply to all of these other transmission technology areas—Real-time and Non Real-time—but even within these classes there are a core set of basic processes that apply to both. These are:

1. Define and Prioritize
2. Generate
3. Transport
4. Validate/Verify
5. Store
6. Analyze
7. Present

There are also a core sub-set of processes that apply within the above processes:

1. Accumulate/Aggregate
2. Modify
3. Improve
4. Secure
5. Quality

In order to manage this complex set of processes there must also be clear data governance policies and methods. In general, data users provide the “who,” “what,” “where,” “when,” and “why” criteria that data scientists need o deliver the “how.” Solutions developed to fulfill the “how” delivers tools that help businesses make informed decisions.

[1] This text is based upon the concluding presentation that Tiffany Gibby of the Tennessee Valley Authority presented on behalf of the Workshop 2 team that developed content for the Data Acquisition, Transmittal, Analysis, and Mining roadmaps on Sep. 18-19, 2013.

Professionals in the electric utility industry have long seen their work as being centered on electricity flows through wires, substations, and other critical infrastructure and systems. Data scientists understand that while data does flow through these hardware systems business can only be optimized when industry professionals understand that data flows through people as well. Just as equipment, staff, and money are rightly viewed as assets, the industry needs also to internalize the fact that data is also a critical asset. Professionals in the information technology, finance, pharmaceutical, and other industries have long valued data itself as a critical business asset, and the utility industry will not be operating at optimal levels of reliability, safety, and productivity until it adopts this mindset as well.

Data is an asset because data is central to operations that can help make money or help save money. In important ways data is money whether it generates revenues or reduces costs through improved efficiency.

Data is an asset that can be expressed in direct monetary equivalents, but realizing this equation requires investments. These investments include innovations in technologies that help deliver the processes outlined above in a consistent, secure, and high-quality manner. They also require investments in data scientist teams to provide the organization a dedicated and expert staff.

The roadmaps covered in the following pages under the heading "Data Acquisition, Transmittal, Analysis, and Mining" convey what is likely the most complex of all the technologies in this document. This is because the elements in these roadmaps relate directly to one or more roadmaps in the other Technology Areas as well as to areas outside of electrical transmission to include enterprise data management, communications, cyber security, and others. Fortunately, resources to address these complexities in ways tailored to the needs of individual organizations exist in the form of dedicated data scientist teams. These specialists can develop tailored technical solutions to fill the Capability Gaps identified in the other roadmaps to address the needs of information consumers and decision makers.

A good team will be able to take the problems in general and simplify data presentations to decision makers. There is research about data definitions, protocols, validation, and analysis of data. An example is to address the question, "What is the most effective presentation of data for a given decision?"

[Ivo] What are the needed technologies? We did not have enough time to talk about hardcore protocol interoperability, analytics. There are opportunities to get the various data sources to work together.

[Tony] Our biggest wish is to overcome siloing of multiple data sources in many locations. How can we bring data together; process, validate, tag, and put it in the right form for the various applications? Then you need a good retrieval process for data mining and specific applications. Each field has need for research.

[Michelle Odjima] The DA team needs another day to get to this level. We need to review all of the other RMs for their applications to help scope our efforts.

[Tiffany] There may not be as much research needed in this area. Much tech transfer can be accomplished from other industries, like finance, communications, and information services.

[Marianna] We discussed in Situation Awareness the challenge to separate bad data from a reliability event. [Tony] BPA has a few TI projects to help with this problem.

[Walt Johnson] We hear about many data issues. The issues of support and governance are real and big. We can benefit from industries that put data as a priority by adopting their techniques. We focused on technology evolution to improve data quality and availability. We focused on data cleansing, management, and handling of meta data and semantic data.

[Ben] Did you look at replication and efficient storage? This is an issue of governance and data definitions. There are work management systems that help manage copies of data. Systems of reference and record require controls.

Section 5

Rollout Webinar, February 4, 2014

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Collaborative Transmission Technology Roadmap

Pilot Project

Feb. 4, 2014

2:00-3:30 p.m. Eastern

Rollout Webcast

Objectives

1) Introduce the Collaborative Transmission Technology Roadmap
2) Discuss the strengths, weaknesses, opportunities, and threats associated with this pilot project and the Roadmap deliverable
3) Determine next steps

Agenda

2:00 p.m.	**Welcome & Introductions**	Larry Bekkedahl, BPA Mark McGranaghan, EPRI Jeff Hildreth, BPA
2:05 p.m.	**Project Overview**	James Hillegas-Elting, BPA
2:10 p.m.	**Content Overview**	Jeff Hildreth, BPA
2:15 p.m.	**Application at BPA**	
2:20 p.m.	**Prioritization Method—Example**	Tugrul Daim, PSU
2:30 p.m.	**Facilitated Discussion Based on S.W.O.T. Questions:** ▪ (*Strengths*) What are the most useful aspects of the document? ▪ (*Weaknesses*) Where is the roadmap unclear, confusing, or inaccurate? ▪ (*Opportunities*) How might this document be used within your organization? ▪ (*Threats*) What barriers might exist in using this document within your organization?	Jeff Hildreth, BPA Workshop Participants
3:20 p.m.	**Summary and Next Steps**	Jeff Hildreth, BPA

Project Partners: *Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy PJM Interconnection ▪ Tennessee Valley Authority ▪ Western Area Power Administration ▪ Xcel Energy*

(version Jan. 17, 2014)

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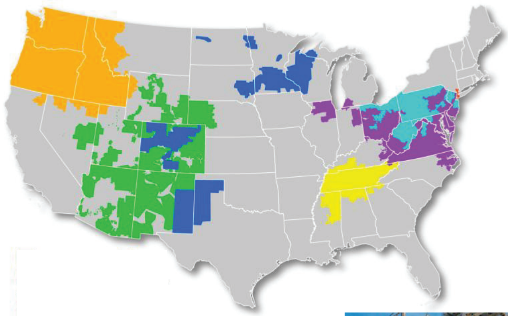
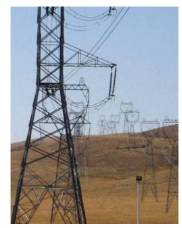
COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP

ROLLOUT WEBINAR

FEB. 4, 2014

Version Feb. 4, 2014





Bonneville Power Administration ▪ Consolidated Edison ▪ Electric Power Research Institute ▪ FirstEnergy ▪ PJM Interconnection ▪ Tennessee Valley authority ▪ Western Area Power Administration ▪ Xcel Energy

WELCOME

Thank you for coming!

Logistics

To minimize distractions,
please mute your phone
when you are not speaking:
*** 6** to **MUTE**
 # 6 to **UN-MUTE**

This call is being **RECORDED** so that we may have capture key outcomes.

Objectives

1. Introduce the *Collaborative Transmission Technology Roadmap*.
2. Discuss the strengths, weaknesses, opportunities, and threats associated with this pilot project and the Roadmap deliverable.
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AGENDA

2:00 p.m.	Welcome & Introductions	Larry Bekkedahl, BPA Mark McGranaghan, EPRI Jeff Hildreth, BPA
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3:20 p.m.	Summary and Next Steps	Jeff Hildreth, BPA

WELCOME

Mark McGranaghan – EPRI

Vice President of Power Delivery and Utilization

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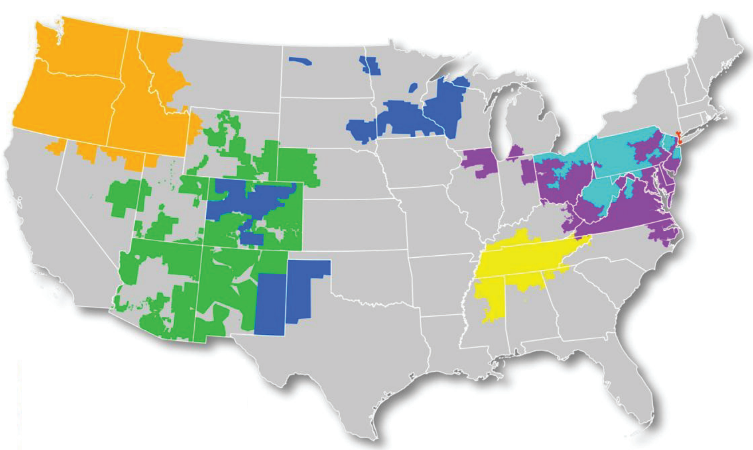
Larry Bekkedahl – BPA

Sr. Vice President of Transmission

INTRODUCTIONS



Project Tasks, Schedule, & Deliverables

May 9 — Principals' Meeting, Charlotte, NC

June 25-26 — Workshop 1, Portland, OR

Aug. 27 — Mini Workshop 2, Charlotte, NC

Sep. 18-19 — Workshop 2, Portland, OR

Nov. 15 — **Publish Transmission Technology Roadmap**

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

- Executives
- Senior leadership
- Senior-level operational managers

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

Content Overview

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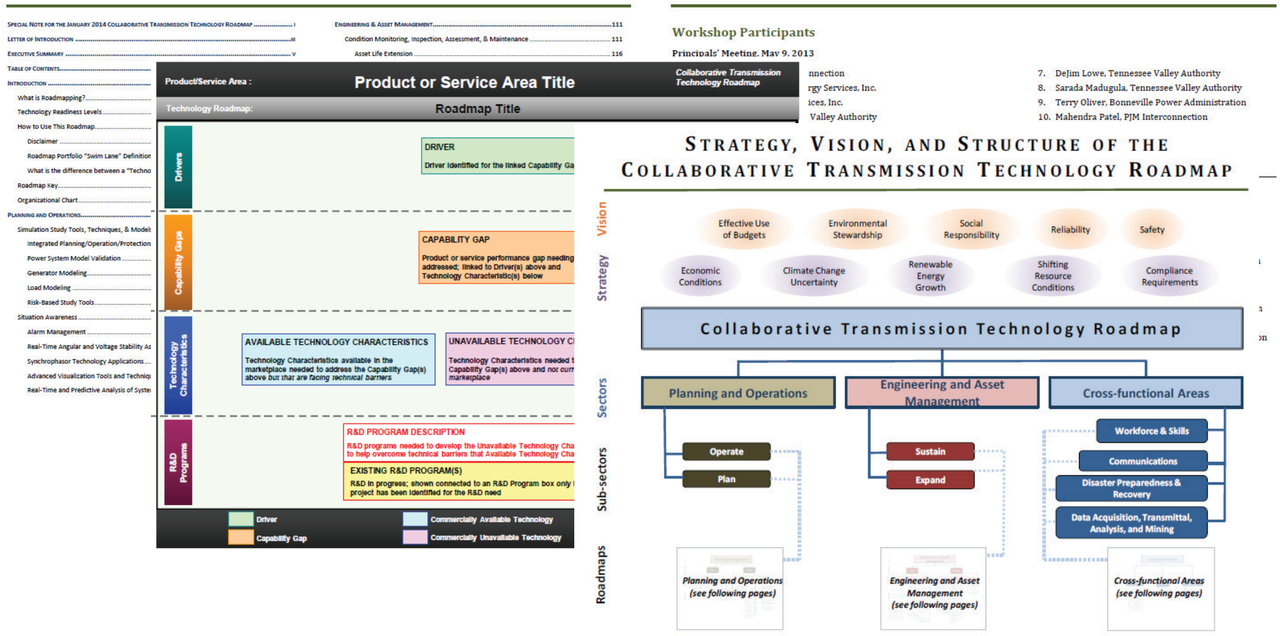
Contributors



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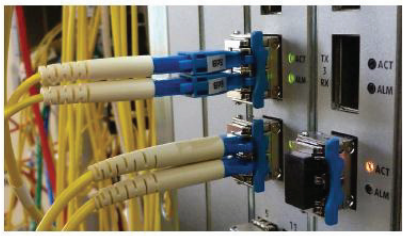
Application at BPA

Operational Multi-Gigabyte Ethernet Transport

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



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

Synchrophasor success lands BPA its first Platts Award

December 17, 2013 facebook and google+ not supported in ie7 Tweet 6

Larry Bekkedahl, senior vice president of Transmission Services, accepted the Grid Optimization award on behalf of BPA's entire synchrophasor team at the Dec. 12 ceremony in New York. (Photo courtesy of Platts Global Energy Awards)

Prioritization Method

Steps

- Quantify importance of Capability Gaps (CGs)
  - Importance = Impact X Urgency
    - Measure impact (1=low, 3= medium, 5=high)
    - Measure urgency (short=5, medium=3, long=1)
- Define relationships between R&D Programs (RDPs) and CGs
- Calculate importance of RDPs
  - Importance for a given RDP = Sum importance of all related CGs (neglects importance of contribution)

Case Analysis

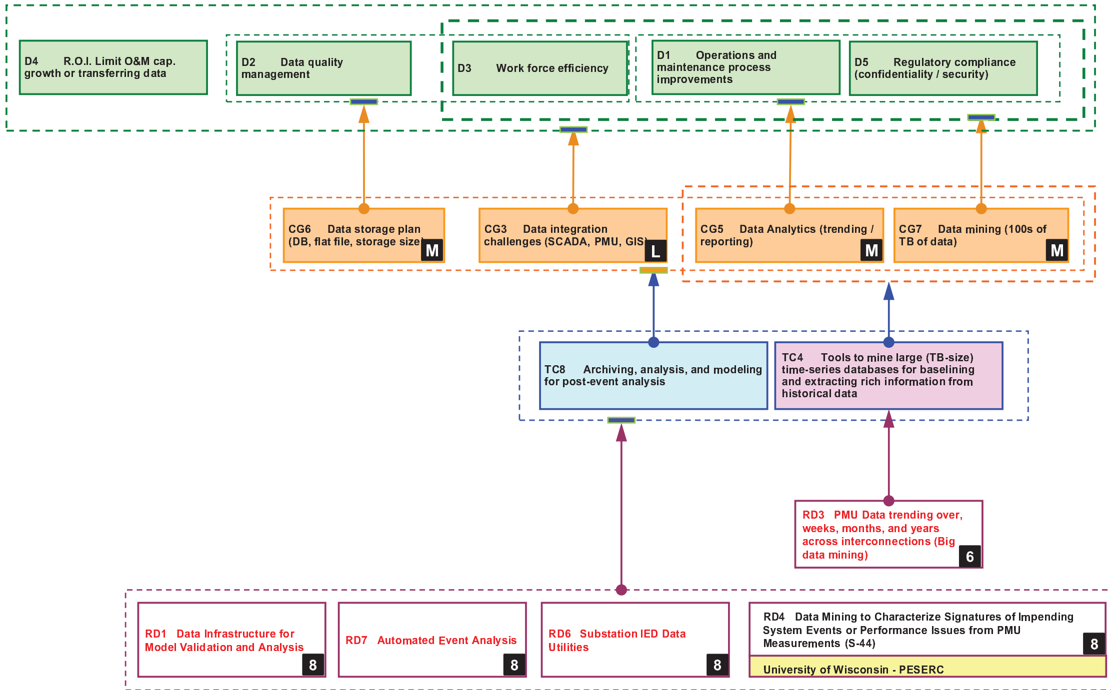
- **Product and Service Area:** Data Acquisition, Transmittal, Analysis and Mining
- **Roadmap:** Data Management for Non-Real Time

Capability Gaps	Impact	Urgency	Total
	Impact (1=Low, 3=Medium, 5=High)	Urgency (5=Short, 3=Medium, 1=Long)	
CG1 Data quality metrics	5	5	25
CG2 CIM (Common Information Model	5	1	5
CG3 Data integration challenges (SCADA, PMU, GIS)	3	1	3
CG5 Data Analytics (trending / reporting)	3	3	9
CG6 Data storage plan (DB, flat file, storage size)	1	3	3
CG7 Data mining (100s of TB of data)	5	3	15
CG8 QA/QC to reduce erroneous data	5	5	25
CG9 Real/non-real time driven maintenance related to data	3	5	15

RD Programs	CGs linked	Score	**Relative**
RD1 Data Infrastructure for Model Validation and Analysis	3, 5, 6, 7	30	**8%**
RD7 Automated Event Analysis Utilities	3, 5, 6, 7	30	**8%**
RD4 Data Mining to Characterize Signatures of Impending System Events or Performance Issues from PMU Measurements (S-44)	3, 5, 6, 7	30	**8%**
RD2 Data Integration based on a Common Semantic model	1, 2, 3, 5, 6, 7, 8, 9	100	**26%**
RD5 Systematic Integration of Large Data Sets for Improved Decision-Making (T-51)	1, 2, 3, 5, 6, 7, 8, 9	100	**26%**
RD8 EPRI Program 161 : Smart Grid Standards and Communications Technology Tracking and Analysis	3, 5, 6, 7, 9	45	**12%**
RD3 PMU Data trending over, weeks, months, and years across interconnections (Big data mining)	5,7	24	**6%**
RD6 Substation IED Data	3, 5, 6, 7	30	**8%**

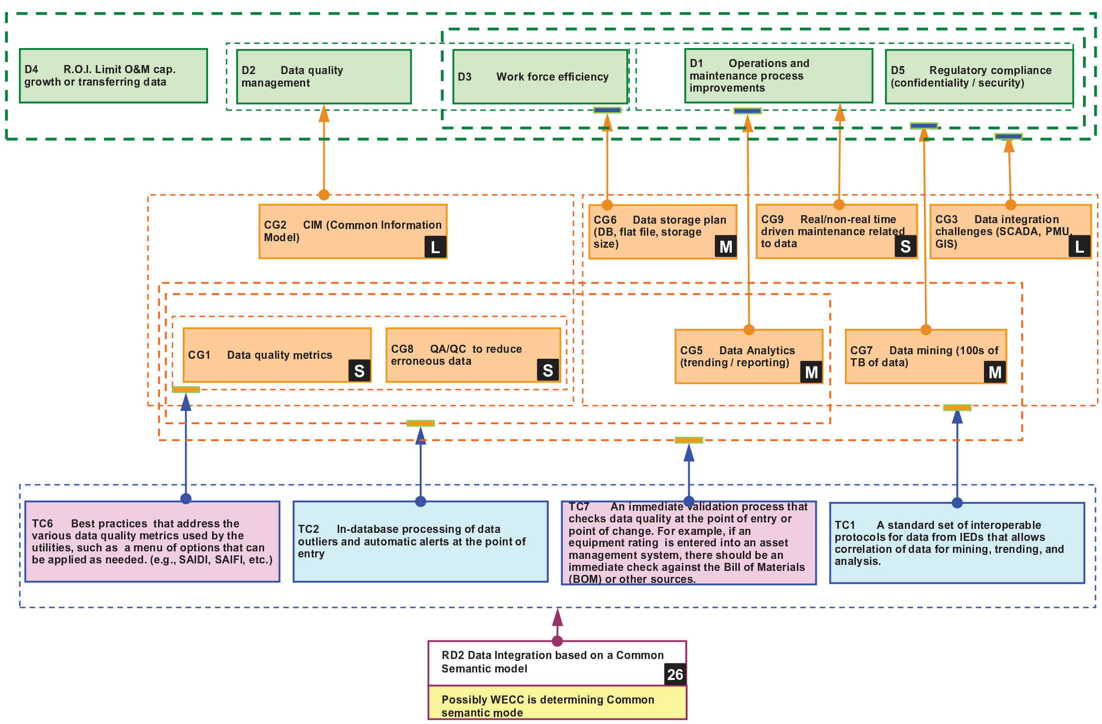
Prioritization Method

Roadmap:
Data Management for Non-Real Time (1/3)

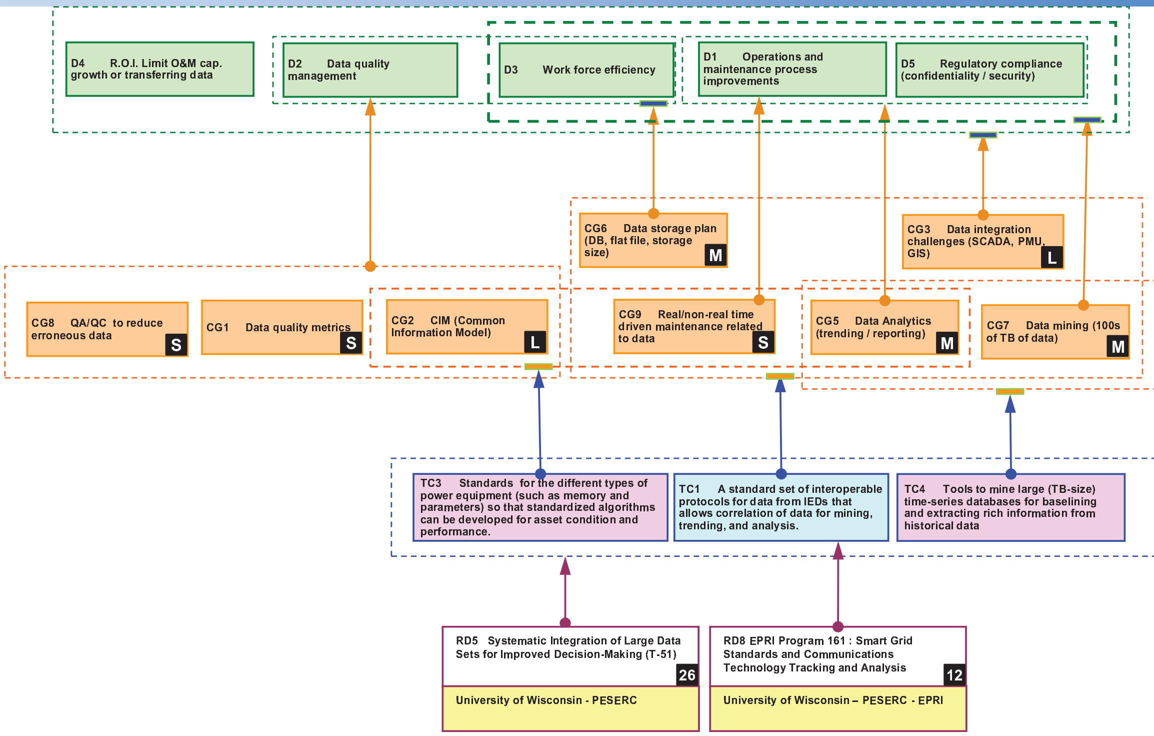


Prioritization Method

Roadmap:
Data Management for Non-Real Time (2/3)



Roadmap:
Data Management for Non-Real Time (3/3)



Strengths

What are the most useful aspects of the document?

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Weaknesses

Where is the roadmap;
unclear,
confusing,
inaccurate?

Opportunities

How might the document be used
within your organization?

Threats

What barriers might exist in using this document within your organization?

Summary and Next Steps

- Plans to respond to the BPA Technology Innovation solicitation March 2014
- Opportunities for Outreach / Announcements
- EPRI PDU Advisory Council mtg., Feb. 2014
- Check-in meeting in about six months

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Thank you for participating!

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COLLABORATIVE TRANSMISSION TECHNOLOGY ROADMAP

PILOT PROJECT

Feb. 4, 2014

ROLLOUT WEBCAST

2:00-3:30 p.m. Eastern

Objectives

1) Introduce the Collaborative Transmission Technology Roadmap
2) Discuss the strengths, weaknesses, opportunities, and threats associated with this pilot project and the Roadmap deliverable
3) Determine next steps

Action Items

1) **James Hillegas-Elting** will:
   a. Include a disclaimer in the revised roadmap document (to be finalized February 14) explicitly stating that this was a collaborative first-step in identifying common research needs among a select group of transmission owners and operators, but the roadmap does not claim to represent a national consensus or a prescriptive national path forward.
   b. Provide participants information regarding the information technology research organization.
   c. Share BPA's public relations plan and offer opportunity for participants to become involved.
2) **Participants** will share any suggestions they might have about other organizations to reach out to with information about the roadmap.

Next Steps

1) Discussion of the roadmapping project at the EPRI Power Delivery and Utilization Program Advisory Council meetings in Huntington Beach, California, February 10-12.
2) Revised version of the roadmap to be submitted to the BPA Technology Innovation Office on February 14 so that this document can be included as part of the agency's annual solicitation (late February; see http://www.bpa.gov/Doing%20Business/TechnologyInnovation/Pages/default.aspx); all webcast participants and pilot project contributors will receive the announcement.
3) Check-in with the collaborating organizations tentatively scheduled for mid-2014 to continue improvement and sustain dialogue.

Discussion Highlights

Strengths

Mark McGranaghan: There is a high level of detail in the technical information provided in the R&D program descriptions.

DeJim Lowe: This provides a useful initial framework to help coordinate research projects with other organizations.

Dave Cenedella: The document effectively captures the issues and challenges shared by others in the industry. It also allows us to see how much other research projects are ongoing at a variety of institutions.

Weaknesses

DeJim Lowe: Some of the diagrams are very busy and crowded. Perhaps spreading diagram elements over a larger area would help illustrate the connections and interrelationships more effectively?

Jeff Hildreth: I agree. One solution we've discussed is to try to limit the number of linkages to the top two or three most critical.

Tugrul Daim: Another option would be for each organization to conduct an internal prioritization exercise to narrow the focus down to a core of content of most interest to the organization. Then, the diagrams could be refined based on this sub-set of content rather than on the entire document.

James Hillegas-Elting: Another approach to resolving this issue would be to develop a user-friendly web-based version that enabled people to search the content quickly and create tailored diagrams that highlight content relevant to the search parameters. I have been in discussion with colleagues internally and at EPRI (Omar Siddiqui) to develop a project plan to migrate the content of the *National Energy Efficiency Technology Roadmap Portfolio* (*EE Roadmap*) to the Internet. The idea currently is to apply a wiki-based approach to create a website with this functionality on the front end and a more easily updated database on the back end. I recently extended this conversation to Jeff Hildreth because the functionality and information technology (IT) architecture would be the same for both the *EE Roadmap* and this Collaborative Transmission Technology Roadmap.

Patricia Hoffman: It will be important to generate momentum with a critical mass of organizations to keep this effort moving forward. You'll want to consider how you can involve more industry and research organizations based on shared interests in prioritized R&D needs.

Dave Cenedella: There's so much information in this document that it's not clear what the key takeaways are or what can be communicated to executive management. The Executive Summary should be something easier to communicate; you might also want to consider how the benefit of this document can be quantified.

James Hillegas-Elting: These are great points. As one step in this direction, this roadmap project and deliverable will be among the topics discussed at next week's EPRI Power Delivery and Utilization Program Advisory Council meetings in Huntington Beach, California. With feedback from you all during this call and from others in the industry next week we'll have more of the information we need to address Dave and Patricia's points.

Opportunities

Larry Bekkedahl: This roadmapping project allows us to identify who is doing what kinds of R&D, and this provides the benefit of avoiding duplicative efforts.

Mark McGranaghan: A challenge is finding the right home for what the industry considers the most pressing issues. It's not clear how we'll maintain this document, who might take charge of managing sections of it, and what the process will be for keeping it updated.

Larry Bekkedahl: Maybe one approach is to find a "champion" organization for each Technology Area or each of the priority Capability Gaps.

Carl Bridenbaugh: Our participation in this project allowed us to validate our involvement in EPRI research projects. We developed a roadmap internally a few years ago and have used this to help guide the research we do through EPRI; seeing the content from the Collaborative Transmission Technology Roadmap validates the research paths that we've taken by showing that we are interested in many of the same pressing issues as others in the industry are.

Tiffany Gibby: Tennessee Valley Authority recently completed a project to develop information technology roadmaps for each of our strategic business units. We then consolidated these individual roadmaps into an enterprise roadmap. I see an opportunity now to cross-check our roadmap with the Collaborative Transmission Technology Roadmap to find areas where we can work with others on areas of mutual concern.

Threats

DeJim Lowe: I'm not sure what the ownership of the process going forward will be, both internally and externally. As Mark stated earlier, who will maintain this document? Also, regarding the prioritization process that Tugrul Daim reviewed earlier, there is a potential issue in the fact that individual organizations may prioritize R&D needs in a way that does not align with other organizations or the broader industry.

Dave Cenedella: If this document gets disseminated widely and regulators become aware of it, will this potentially create challenges for anyone? Does this document represent a proactive approach that industry has taken on some of the key issues that regulators may be concerned with? Perhaps this is an issue we should discuss further?

Larry Bekkedahl: My experience with regulators is that they prefer to have a document that they can refer to when they're having discussions with industry players, so I think this roadmap would be of benefit in this regard.

Joe Waligorski: It's important to note that this document doesn't represent all of the industry, nor even all of the technology areas of concern to the industry, just a slice.

Al Choi: Perhaps there is a need for a clearer disclaimer in the document that explicitly addresses these points?

James Hillegas-Elting: We've approached this project from the beginning as a collaborative first-step in identifying common research needs among a select group of transmission owners and operators, and we've purposely not claimed that this effort represents a national consensus or a national, prescribed path forward. These points are included in the text of the current version of the roadmap, but threaded throughout rather than stated clearly and concisely in a disclaimer. This is an important thing to include so I will ensure that such a disclaimer is included in the revised version that I'll be finalizing by the end of next week.

Other Topics

Larry Bekkedhal: Regarding outreach, we plan to discuss this at an upcoming North American Transmission Forum meeting and with some other regional organizations. We'd appreciate hearing (during this call or after) any suggestions of other groups to reach-out to.

Mark McGranaghan: One suggestion is the concurrent North American Transmission Forum and North American Energy Standards Board (NAESB) meeting this fall, or the NAESB meeting in March.

Tiffany Gibby: You might also consider the Utility Information Technology Benchmark (UNITE) consortium. They've been particularly active in benchmarking information technology groups for the utility industry. Also, an online portal of some kind to facilitate collaboration and sharing would also be useful.

Michelle Odajima: The current roadmap is good but particularly in the IT realm the content that we developed as part of this project will be dated within six months.

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Mark McGranaghan: At EPRI we have a new research initiative focused on IT and data management. One potential "owner" of this section of the roadmap could be EPRI, since we have the structure and we're building the collaboration to address this topic.

James Hillegas-Elting: We had a similar issue arise when discussion agency research ideas for the energy efficiency sector. Some of our subject matter experts sought to address pressing issues around "big data"—data management, IT, communications systems, etc.—but rather than pursue this only within one of the agency's business lines our Chief Technology Innovation Officer Terry Oliver suggested that we work on this collaboratively within and beyond the agency. One option is the EPRI initiative that Mark referred to. Another is a research consortium that Terry Oliver suggested a few weeks ago but that has slipped my mind; I will take an action item provide this reference for you all. [*Note: This organization is the Smarter Energy Research Institute, http://www.research.ibm.com/client-programs/seri/*].

Jeff Hildreth: Having heard James' brief overview of the wiki website idea, do the people on this call think this is a worthwhile idea?

Mark McGranaghan: It would be worth having more discussion on this both because it's a good suggestion for a way to make the roadmap content more accessible and also because of EPRI's data management initiative.

Joel Scruggs: We'll be developing some announcements and news items about this roadmapping project over the coming months. For those on this call who are interested, this would be a good opportunity to coordinate our outreach and to contribute as well.

James Hillegas-Elting: After this webcast I'll provide some additional information about BPA's public relations plan as it relates to the roadmap project.

Jeff Hildreth: Thanks again to everyone who contributed their time and expertise to this project. We see this as an important step in building the proactive collaboration necessary to continue to deliver electricity safely, reliably, and cost-effectively. We always welcome your questions and comments and invite you to contact James, Navin, or I at any time.

Participants

Bonneville Power Administration

1) Larry Bekkedahl, Senior Vice President of Transmission
2) James Bowen, Program Analyst–Technology Innovation
3) Judith Estep, Project Management Officer–Technology Innovation
4) Jeff Hildreth, Electrical Engineer–Transmission
5) James V. Hillegas-Elting, Project Manager
6) Joel Scruggs, Public Affairs Specialist

Electric Power Research Institute

1) Navin Bhatt, Technical Executive
2) Daniel Brooks, Senior Program Manager
3) Robert Entriken, Senior Project Manager
4) Ivo Hug, Marketing Manager
5) Mark McGranaghan, Vice President of Power Delivery and Utilization
6) Andrew Phillips, Director, Transmission

Portland State University Engineering and Technology Management Dept.

1) Dr. Tugrul Daim, Professor

Consolidated Edison Co. of New York

7) Ray O'Sullivan, Program Manager in Research and Development
8) Michael Simione, Department Manager–Electrical Engineering

FirstEnergy Corporation

2) Carl Bridenbaugh, Vice President of Transmission
3) Eileen M. Buzzelli, Director, FirstEnergy Technologies
4) Joe Waligorski, Delivery Operations Technical Advisor

PJM Interconnection

5) Sarah Burlew, Manager, Applied Solutions

Tennessee Valley Authority

6) Tiffany Gibby, Project Control Specialist
7) DeJim Lowe, Senior Project Manager
8) Bruce Rogers, Director, Technology Innovation

U.S. Department of Energy

9) Patricia Hoffman, Assistant Secretary for the Office of Electricity Delivery and Energy Reliability

Xcel Energy Services, Inc.

10) Ted Carr, Principal Engineer
11) Dave Cenedella, Information Technology Manager
12) Al Choi, Manager, Xcel Energy Next Generation
13) Jason Espeseth, Transmission Planning Engineer
14) Teresa Mogensen, Vice President of Transmission
15) Michelle Odajima, Senior System Sustainability Analyst
16) Mark Tiemeier

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