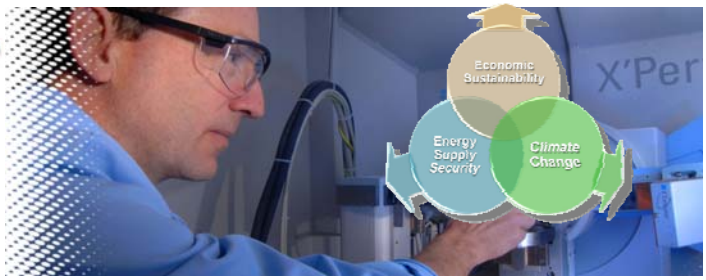

Cost and Benefit Analysis Framework
EPRI Smart Grid Advisory Meeting
June 24, 2009
Red Bank, New Jersey

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Director, Integrated Electric Power Systems
Office of Systems Analysis and Planning

Smart Grid Demonstrations

- **Sponsors – DOE OE R&D and EPRI**
  - Funding & direction
- **Project Management – NETL PMC and EPRI**
  - Award and manage RDSI and EPRI demonstrations
- **Core CBA Team – ORNL/Smart Grid Experts**
  - Develop common CBA methodology
  - Consult on RDSI and EPRI demonstrations
- **Project-specific cost benefit analysis – NETL OSAP**
  - Apply common methodology to RDSI and EPRI projects

Core CBA Team Member	Organization
Ahmad Faruqui	The Brattle Group
Russ Lee/Travis Smith	Oak Ridge National Laboratory
Dan Violette	Summit Blue
David Walls/Forrest Small	Navigant Consulting
Bruce Renz	Renz Consulting
Sponsor Managers	
Bernie Neenan	EPRI
Steve Bossart	DOE NETL

RDSI Project Name	Contractor PI	DOE COR	Core CBA Team Member	OSAP CBA Team Member
West Virginia Super Circuit	Harley Mayfield	Tom George	Travis Smith	Keith Dodrill
Integrated Auto DG Technologies Demonstration	Roger Weir	Tom George	Dan Violette	Kristin Gerdes
Santa Rita Jail Microgrid	Bruce Dickinson	Steve Waslo	Ahmad Faruqui	Rodney Geisbrecht
Peak Load Reduction on Distribution Feeders Using DER	Dennis Sumner	Mario Sciulli	Travis Smith	Kristin Gerdes
Interoperability of Demand Response Resources Demonstration in New York	Frank Doherty	Tom George	David Walls	Rodney Geisbrecht
The Perfect Power Prototype for the Illinois Institute of Technology	Mohammad Shahidehpour	Steve Waslo	Bruce Renz	Kristin Gerdes
Beach Cities Microgrid	Rick Gardner	Mario Sciulli	Forrest Small	Keith Dodrill
Managing Distribution System Resources for Improved Service Quality and Reliability, Transmission Congestion Relief and Grid Support Functions	Terry Surles	Mario Sciulli	Ahmad Faruqui	Keith Dodrill
Dramatic Residential Demand Reduction in the Desert Southwest	Robert Boehm	Tom George	Bruce Renz	Rodney Geisbrecht

Smart Grid Demonstration
Cost and Benefit Analysis Methodology

- **Objectives:**
  - Develop and apply common cost and benefits methodology across all Smart Grid demonstrations
  - Publish methodology including underlying rules and assumptions
  - Enable fair and consistent comparison of different approaches to Smart Grid implementation
  - Ensure that methodology can easily accommodate changes and expansion

Application of CBA Methodology
to Smart Grid Demonstration Projects

- **Assist demonstration project team in establishing project goals, metrics, and data requirements**
- **Determine specific data to be collected, frequency of collection, & method of collection**
- **Determine approach to use raw data**
- **Determine baseline costs and performance prior to introduction of Smart Grid technologies and systems**
- **Determine demonstration costs and performance**
- **Compare cost and performance of demonstration circuit(s) before and after introduction of Smart Grid technologies and systems**

Methodological Approach Has Ten Steps

Characterize the Project

1. Review project's technologies/elements and goal
2. Assess the Smart Grid principal characteristics, each having one or more metrics, that are reflected in the project
3. Establish project baseline

Estimate Benefits

4. Identify, from standardized set, the smart grid functions which each project element could provide and what will be demonstrated
5. Map each function onto a standardized set of benefit categories
6. Obtain data needed from project to calculate each type of benefit
7. Quantify the benefits
8. Monetize the benefits

Compare Costs to Benefits

9. Estimate the relevant costs
10. Compare costs to benefits

Cost and Benefit Guidance

- **Cross-reference benefits with seven Smart Grid characteristics**
- **Consider operation, consumer, and societal benefits**
- **Monetized benefits can be either cost savings or cost avoidance**
- **Keep algorithms, rules, and assumptions as simple as possible**
- **Consider applying ranges for assumptions (i.e,. confidence levels)**
- **Consider need for sensitivity analyses**
- **Baseline data determined from historical data and/or collection of current data on demonstration circuits**
- **Review scope of RDSI and EPRI demonstration projects to determine goals and cost & benefits**
- **Review previous CBA methodologies that were applied to electric grid demonstrations**

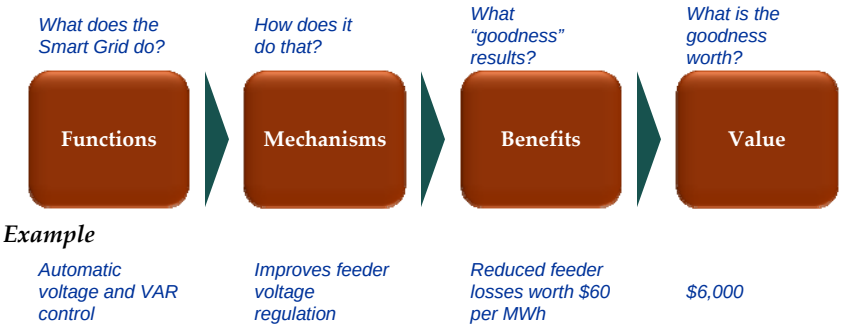
Benefits

- **Level 1 -- Observation**
  Environmental emissions are reduced
  Lost-time accidents are reduced
  Outages are reduced

- **Level 2 -- Quantification**
  Carbon dioxide emissions are reduced by 10% or 5000 tons per year
  Lost-time accidents are reduced by 20% or 5 per year
  SAIFI and SAIDI are reduced by 10%

- **Level 3 – Monetization**
  (Cost savings or cost avoidance)
  Carbon dioxide emissions reduction saves $100,000
  Reduction in lost time accident saves $50,000
  SAIDI and SAIFI reductions save $500,000 for utility

Functions, Mechanisms, Benefits and Value



Progress in Developing CBA Framework

- Developed general approach that includes consideration of principal characteristics and that provides step-by-step approach to estimate project benefits
- Developed comprehensive definition of general categories of benefits
- Developing details of each step of methodical approach
- Applying general methodology to nine RDSI projects
- Addressing issues encountered and status

Overview of Discussion About Our Progress

- Types of projects in RDSI/Smart Grid demonstrations
- Goals of each project
- Definition of general categories of benefits
- Methodological approach
- Generic example
- Issues encountered and status

Typical Smart Grid Elements Included in Demonstrations

- **Advanced Metering Infrastructure/Smart Meters**
- **Demand response/load control**
- **Consumer gateway linking utility and consumer**
- **Distributed generation**
  - Solar PV, fuel cells, wind power, CHP, biodiesel generator…
- **Energy storage**
  - NAS Battery, PHEV
- **Distribution automation**
- **Distribution feeder reconfiguration**
- **Automated voltage and VAR control**
- **Real time load management and measurement**
- **Real time load transfer**
- **Automated islanding and reconnection**
- **Diagnosis and notification of equipment condition**

Typical Project Goals

- **Reduce peak load met by centralized generation**
- **Reduce outages**
- **Quickly restore outages**
- **Demonstrate islanding**
- **Increase consumer participation in demand response programs**

Framework takes various goals and expresses them in terms of a consistently-stated set of benefits that can apply to other projects

Types of Benefits
Consistently defined
Estimated in the same way for all projects

- **Broad categories of benefits**
  - Economic (reduced costs)
  - Reliability (interruptions and power quality)
  - Environmental (emissions and hazardous materials)
  - Safety
  - Energy independency & security
- **Stakeholders who benefit**
  - Utilities/Ratepayers
  - Consumers
  - Society

Examples of Demonstrable Benefits

- **Electricity Service Provider**
  - **Operational Reduced costs to service provider associated with: metering & billing, outage & work force management, reduced energy losses, optimize asset utilization, reduce equipment failure; reduce number, duration, and extent of outages**
  - **Asset Management System planning, maintenance**
- **Consumer**
  - **Reduced business loss from outages and PQ events, information access, reduced energy bills from energy management, participate in DR programs, reduced peak charges from connection of DG and storage, reduce transportation costs**
- **Societal**
  - **Reduced emissions, economic development, improved grid security, revolutionize transportation sector to reduce dependence on foreign oil**

Hypothetical project to demonstrate a microgrid

Primary Smart Grid Systems	Project Goals
• Distribution Automation for automatic switching (FLISR) • AMI • Customer owned PV • Utility owned energy storage • OMS/DMS	• Improve reliability • Achieve reduce feeder peak load • Manage feeder voltage and VAR • Intentionally island customers • Manage variable renewable resources

Distribution System Factors
• Build new distribution to tie feeders • Install additional capacitor bank

Smart Grid Functions and Benefits

Smart Grid Functions	Key Benefits to Quantify
• Adaptive protection • Automated feeder switching • Automated islanding and reconnection • Automated voltage and VAR control • Enhanced fault protection • Real-time load measurement and management • Backup generation • Demand response • Energy storage	• Reduced outage frequency • Reduced outage duration • Reduced restoration costs • Deferred distribution capacity investments • Reduced distribution operations cost • Reduced electricity costs • Avoided on-peak charges • Reduced peak demand • Reduced peak losses • Reduced reserve margin requirement

Potential Information to be Reported

Proposed Information to be Reported		
Reliability	*Distribution O&M*	*Load and Generation*
• *SAIFI (microgrid system)* • *SAIDI (microgrid system)* • *MAIFI (microgrid system)* • *% of SAIFI caused by feeder faults* • *% of SAIFI caused by equipment failure*	• *OH line expense* • *UG line expense* • *S/S maintenance expense* • *Inspection expense* • *OH maintenance expense* • *UG maintenance expense* • *Time required per switching event* • *Time required per restoration job* • *Vehicle miles driven*	• *Hourly S/S loads (P/Q)* • *Hourly feeder loads (P/Q)* • *Hourly DG output (P/Q)* • *Hourly customer loads* • *Hourly feeder and customer voltage* • *Log of ISO and utility demand response requests (frequency and size)* • *Log of microgrid demand response actions* • *Log of microgrid frequency during islanded condition*

Issues Encountered

- **Availability of data from the projects**
- **Adequacy of duration and size of demonstration to determine benefits**
- **Estimation of national benefits versus limited demonstration benefits**
- **Defining benefits in a uniform way so that estimates are both comprehensive and mutually exclusive**
- **Determination of baseline**
- **Monetization of benefits**
- **Different externalities from baseline and demonstration**

Next Steps

- Complete developing details of each step of methodology, especially specifics of data needs, baseline definitions and monetization of benefits
- Complete consideration of each of the nine DOE RDSI projects, and perhaps EPRI
- Complete analysis of issues such as extending to a national context
- Complete report on the methodology, application to the nine projects, and discussion of issues
- Develop code (e.g., in Excel) to implement the methodology in the next phase