U.S. Department of Energy

Office of Electricity Delivery and Energy Reliability

Metrics and Benefits Analysis for the ARRA Smart Grid Programs

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Office of Electricity Delivery and Energy Reliability
U.S. Department of Energy

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140 ARRA-Funded Smart Grid Projects

SGIG/SGDP/RDSI Areas of Smart Grid Technology Deployment				
Customer Systems	Advance Metering Infrastructure	Electric Distribution Systems	Electric Transmission Systems	Equipment Manufacturing
				
• Displays • Portals • Energy management • Direct load controls	• Smart meters • Data management • Back office integration	• Switches • Feeder optimization • Equipment monitoring • Energy Storage	• Wide area monitoring and visualization • Synchrophasor Technology • Energy Storage	• Energy devices • Software • Appliances

Analytical Focus

Investments

- Equipment Manufacturing
- Customer Systems
- Advanced Metering Infrastructure
- Electric Distribution Systems
- Electric Transmission Systems
- Integrated and/or Crosscutting Systems
- Energy Storage Systems

Transformation

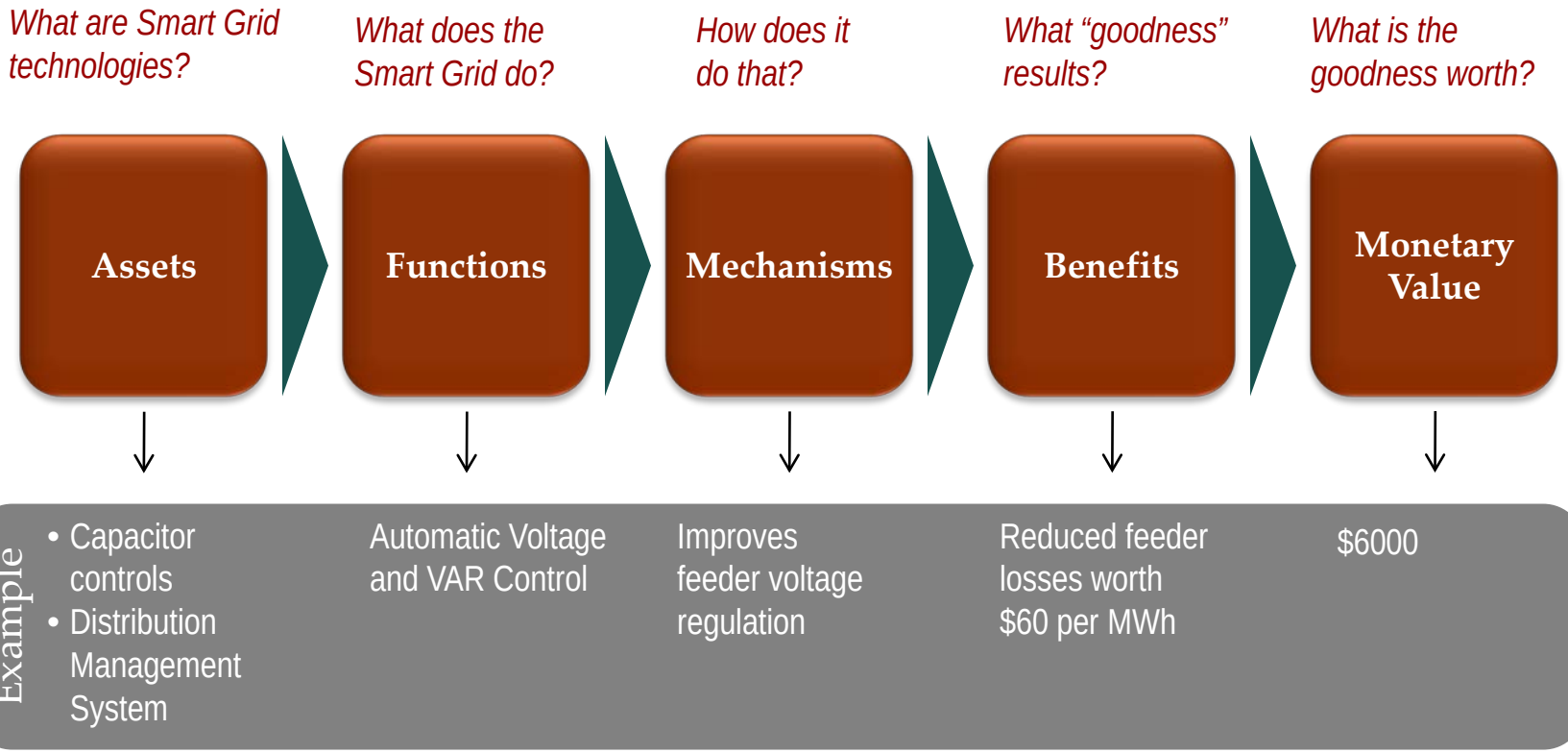
Customer Empowerment

Advanced Grid Functionality and Performance Improvements

Results

- Reduced Peak Load and Consumption
- Operational Efficiency (e.g., O&M cost reduction)
- Energy Efficiency (e.g., reduced line losses)
- Grid Reliability
- Adoption of Synchrophasor Technology
- Environmental Benefits (e.g., reduced CO_2 emissions)

DOE Analytical Approach



Benefits Analysis Framework: Assets to Functions

Smart Grid Assets	Functions												
	Fault Current Limiting	Wide Area Monitoring, Visualization, and Control	Dynamic Capability Rating	Power Flow Control	Adaptive Protection	Automated Feeder Switching	Automated Islanding and Reconnection	Automated Voltage and VAR Control	Diagnosis & Notification of Equipment Condition	Enhanced Fault Protection	Real-Time Load Measurement & Management	Real-time Load Transfer	Customer Electricity Use Optimization
Advanced Interrupting Switch										•			
AMI/Smart Meters								•			•		•
Controllable/regulating Inverter							•	•					
Customer EMS/Display/Portal													•
Distribution Automation					•	•	•	•				•	
Distribution Management System			•		•	•	•	•			•	•	
Enhanced Fault Detection Technology										•			
Equipment Health Sensor			•						•				
FACTS Device				•									
Fault Current Limiter	•												
Loading Monitor			•						•			•	
Microgrid Controller							•						
Phase Angle Regulating Transformer				•									
Phasor Measurement Technology		•	•	•	•		•	•		•			
Smart Appliances and Equipment (Customer)													•
Software - Advanced Analysis/Visualization		•	•										
Two-way Communications (high bandwidth)		•			•	•	•	•			•	•	
Vehicle to Grid Charging Station													•
VLI (HTS) cables				•									

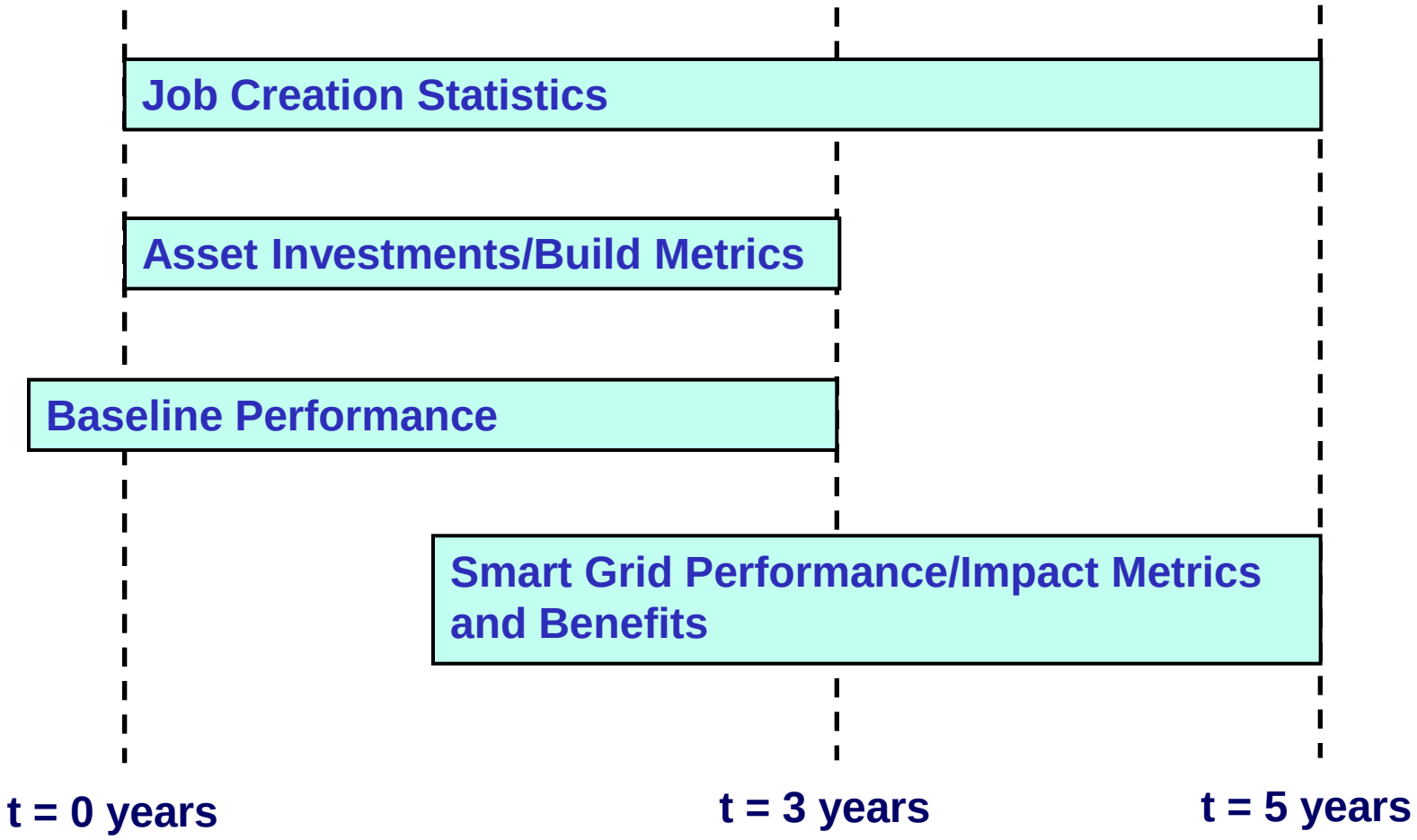
Benefits Analysis Framework: Functions to Benefits

Benefits			Functions													Energy Resources		
			Fault Current Limiting	Wide Area Monitoring, Visualization, and Control	Dynamic Capability Rating	Power Flow Control	Adaptive Protection	Automated Feeder Switching	Automated Islanding and Reconnection	Automated Voltage and VAR Control	Diagnosis & Notification of Equipment Condition	Enhanced Fault Protection	Real-Time Load Measurement & Management	Real-time Load Transfer	Customer Electricity Use Optimization	Distributed Generation	Stationary Electricity Storage	Plug-in Electric Vehicles
Economic	Improved Asset Utilization	Optimized Generator Operation		•													•	•
		Deferred Generation Capacity Investments													•	•	•	•
		Reduced Ancillary Service Cost		•						•			•		•	•	•	•
		Reduced Congestion Cost		•	•	•									•	•	•	•
	T&D Capital Savings	Deferred Transmission Capacity Investments	•	•	•	•									•	•	•	•
		Deferred Distribution Capacity Investments			•								•	•	•	•	•	•
		Reduced Equipment Failures	•		•						•	•						
	T&D O&M Savings	Reduced Distribution Equipment Maintenance Cost									•							
		Reduced Distribution Operations Cost						•		•								
		Reduced Meter Reading Cost											•					
	Theft Reduction	Reduced Electricity Theft											•					
	Energy Efficiency	Reduced Electricity Losses								•			•	•	•	•	•	
	Electricty Cost Savings	Reduced Electricity Cost													•	•	•	•
Reliability	Power Interruptions	Reduced Sustained Outages					•	•	•		•	•	•			•	•	•
		Reduced Major Outages		•					•				•	•				
		Reduced Restoration Cost					•	•			•	•						
	Power Quality	Reduced Momentary Outages										•					•	
		Reduced Sags and Swells										•					•	
Environmental	Air Emissions	Reduced CO_2 Emissions				•		•		•			•		•	•	•	•
		Reduced SO_x, NO_x, and PM-10 Emissions				•		•		•			•		•	•	•	•
Security	Energy Security	Reduced Oil Usage (not monetized)						•			•		•					•
		Reduced Widescale Blackouts		•	•													

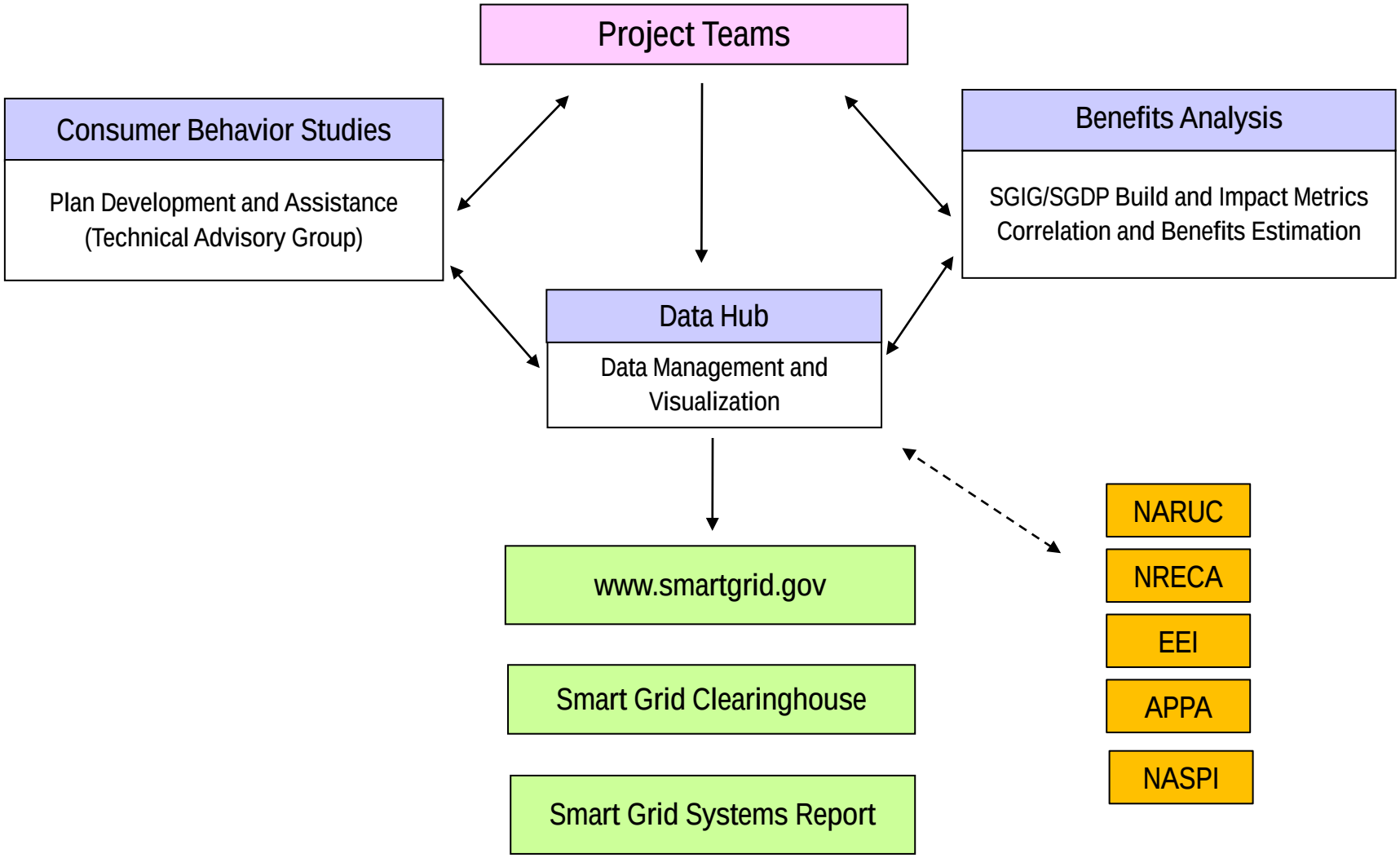
Consumer Behavior Studies

- Approximately 10 projects will undertake a rigorous consumer behavior study to examine consumer acceptance and response to dynamic pricing tariffs
- The DOE Technical Assistance Group is working with project teams to ensure that data collection and analysis efforts will satisfy goals
  - Valid control and treatment groups (i.e., to understand the response related to pricing, enabling technology, customer education)
  - Randomization of treatment groups
  - Customer demographic information being collected (with protection of information)
- DOE will produce a rich dataset correlating demand, rate tariff design, and customer-level information, as well as conduct a meta-analysis of the results (e.g., to examine factors affecting customer acceptance of rate plans)

Key Components for Information Gathering



Data Management and Analysis



Reporting

- Smart Grid Investment Grant Program:
  - Build metrics quarterly (per project and aggregated)
  - Impact metrics semi-annually (aggregated)
  - Meta-Analysis of Performance Impacts, including business case analysis
  - Results of Consumer Behavior Studies:
    - Evaluation Report (per project)
    - Meta-Analysis of consumer behavior studies
    - Interval data (raw data)
- Smart Grid Demonstration Program:
  - Build metrics quarterly (per project and aggregated)
  - Technology Performance Reports

Current Efforts with Stakeholders

- Scope:
  - Address data gathering and analysis issues
  - Advance benefits estimation methodology to support business case analysis (and cost/benefit analysis)
  - Share consumer behavior study lessons learned
- Stakeholders:
  - NARUC and PUCs (focus group)
  - Edison Electric Institute
  - Electric Power Research Institute (EPRI)
  - American Public Power Association (APPA)
  - National Rural Electric Cooperatives Association (NRECA)
  - North American Synchrophasor Initiative (NASPI)
  - Consumer advocate groups (NASUCA)

Potential Areas for EAC Comment

- Is the analytical approach sound? Are we missing anything? Are there special analyses we should consider?
- What should be the objectives of our stakeholder strategy? Are we achieving them?
- How should we convey the progress and impact of the ARRA programs? What should be our communications strategy?
- How do we integrate the ARRA programs with the corporate R&D program?