Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments

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Distribution Systems and Planning Training
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Outline of Presentation

GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

- Presentation is based on draft Berkeley Lab report
- Utility-facing grid modernization concepts
- Grid modernization benefit-cost analysis (BCA) concepts
- Review of recent utility grid modernization plans
  - Focus on BCAs
- How to address key challenges of grid modernization BCAs

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Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments

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Considerable progress has been made in recent years to support benefit-cost analysis (BCA) of utility grid modernization plans. This work includes development of taxonomies for articulating key aspects of relevant technologies, new evaluation approaches, and practices for categorizing grid modernization components. However, planning practices have not kept pace with such work.

A review of 21 recent utility grid modernization plans indicates a wide variety in the assumptions, methodologies, justification and documentation. The level of analytical rigor also varies widely.

Several aspects of utility-facing grid modernization make BCA more challenging than for other utility investments. Following is a summary of these challenges and potential approaches for addressing them.

Challenge	Potential Approaches
Documenting the purpose of each grid modernization component	• Specify a standard taxonomy for grid modernization • Define purpose and role of grid modernization components
Choosing BCA framework	• Articulate the BCA framework upfront • Focus on two tests: Utility Cost test and Regulatory test • Use the least-cost, best-fit approach where warranted
Choosing discount rate	• Choose a discount rate that reflects state regulatory goals • Conduct sensitivities using different discount rates
Accounting for interactive effects	• Use the least-cost, best-fit approach where warranted • Use scenarios with different combinations of components • Conduct BCA for grid modernization components in isolation
Accounting for qualitative benefits	• Use the least-cost, best-fit approach where warranted • Establish metrics to assess the extent of benefits • Apply methodologies to make qualitative benefits transparent
Addressing customer equity	• Give more weight to the Utility Cost test • Document beneficiaries • Estimate long-term bill impacts
Ensuring net benefits for customers	• Limit cost recovery to the proposed costs in grid modernization plans • Limit cost recovery to achievement of proposed benefits • Establish metrics to monitor achievement of benefits

Utility-Facing
Grid Modernization Concepts

Utility Facing Versus Customer Facing

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Grid Modernization

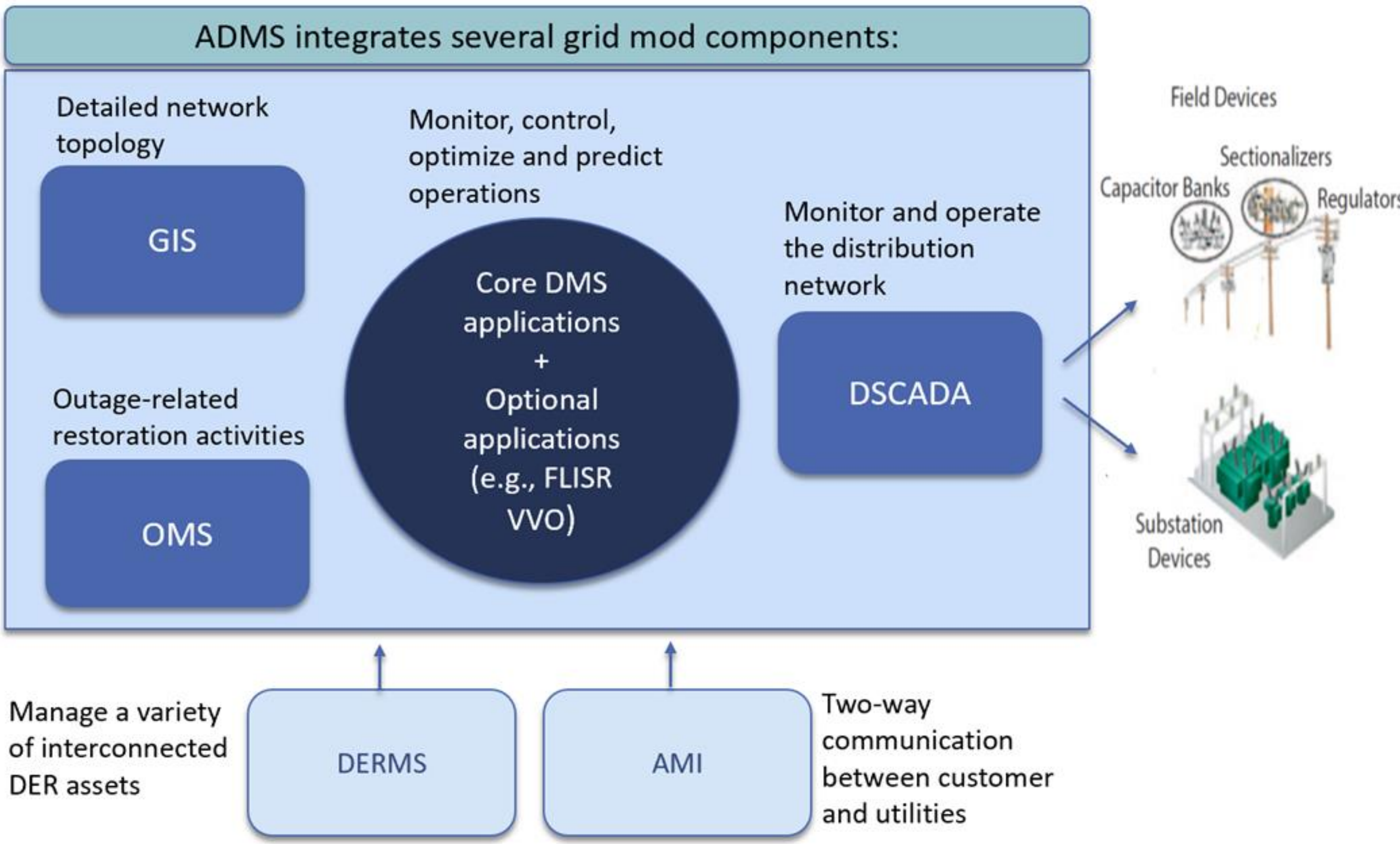
Utility Facing

- Advanced distribution management system (ADMS)
- Geographic information system (GIS)
- Distribution system supervisory control and data acquisition (DSCADA)
- Outage management system (OMS)
- Distributed energy resource management system (DERMS)
- Fault location, isolation, & service restoration (FLISR) a/k/a/ dist. automation
- Volt-var optimization (VVO)
- Advanced metering infrastructure (AMI)
- Network monitoring:
  - Substation devices
  - Field (feeder) level devices

Customer Facing

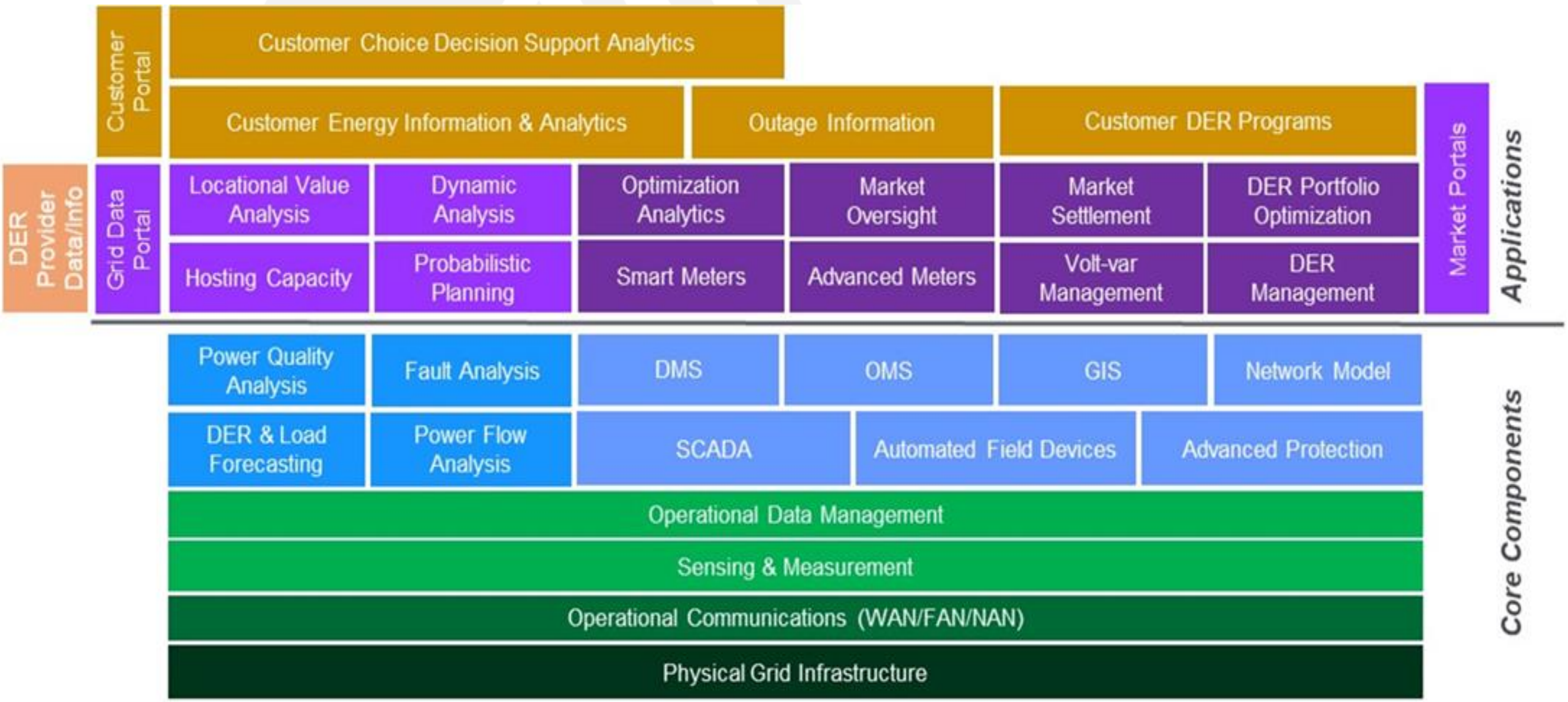
- Energy efficiency
- Demand response
- Distributed generation
- Storage
- Electric vehicles
- Advanced meters
- Third-party access
- Customer data
- Cybersecurity

Interdependence of Components



Source: Adapted from World Bank, *Practical Guidance for Defining a Smart Grid Modernization Strategy: The Case of Distribution,* 2017.

Core (Platform) Components and Applications



Source: US DOE 2017, *Modern Distribution Grid: Decision Guide,* Volume III, page 26, Figure 8.

Grid Modernization Benefit-Cost Analysis Concepts

BCA Regulatory Contexts

1. Utility seeking review of costs before spending
   - Typically in a case dedicated to review of proposed investments
   - Utility often asks for regulatory guidance or approval
   - Allows for focused review of proposal
   - Utility can be held accountable to cost forecasts
   - Costs can be reduced or rejected before incurred
2. Utility seeking recovery of costs after spending
   - Typically in a rate case
   - Allows for review in context of other costs
   - Grid modernization issues might be one of many contentious issues
   - Difficult to modify, reduce, or disallow costs after they are spent

► Most grid modernization plans are submitted prior to spending

Utility-Facing Grid Modernization Benefits

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Benefit	Utility System	Specific Customers	Society
Reduced O&M costs	✓		
Reduced generation capacity costs	✓		
Reduced energy costs	✓		
Reduced T&D costs and losses	✓		
Reduced ancillary services costs	✓		
Increased system reliability	✓		
Increased safety	✓		
Increased resilience	✓	✓	✓
Increased DER integration	✓	✓	
Improved power quality		✓	
Reduced customer outage costs		✓	
Increased customer satisfaction		✓	
Increased customer flexibility and choice		✓	
Environmental benefits			✓
Economic development benefits			✓

Utility-Facing Grid Modernization Costs

Cost	Utility System	Specific Customers	Society
Incremental utility O&M costs	✓	-	-
Incremental utility capital costs	✓	-	-
Incremental T&D costs	✓	-	-
Incremental ancillary service costs	✓	-	-

Utility-facing grid modernization costs are generally recovered from all customers.

Traditional BCA Tests for **Energy Efficiency**

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- The California Standard Practice Manual has been widely used for EE
- Describes five standard cost-effectiveness tests
- Three tests commonly used for EE BCA:
  - Utility Cost test: impacts on the utility system
  - Total Resource Cost test: impacts on utility system and participants
  - Societal Cost test: impacts on society
- These tests are increasingly being used to assess grid modernization, DERs, and related initiatives
- But the CA Manual does not address current needs:
  - Does not address regulatory policy goals
  - Has been interpreted inconsistently
  - Does not address some key DER issues

Source: California Public Utility Commission, *Standard Practice Manual*, 2001.

Emerging BCA tests for EE: the National Standard Practice Manual

- ► Designed to update, improve, and replace the California SPM
- ► Includes a set of fundamental BCA principles
- ► Identifies the importance of accounting for regulatory goals
- ► Introduces the "regulatory perspective"
- ► Articulates that there are multiple options for BCA tests
- ► Provides a framework for determining a primary BCA test
- ► Introduces the "Regulatory test"
  - Accounts for a state's regulatory goals
  - Broader than the Utility Cost test
  - Narrower than the Societal Cost test

Source: National Efficiency Screening Project, *National Standard Practice Manual (NSPM) for Assessing the Cost-Effectiveness of Energy Efficiency*, May 2017

BCA Framework for Grid Mod: US DOE (1 of 2)

DOE report divides grid modernization expenditures into four types:

No.	Purpose of Expenditure	BCA Approach
1	To replace aging infrastructure, connect new customers, and other traditional services	Apply a "best-fit / least-cost" approach
2	To maintain reliable operations on a grid with much higher levels of distributed energy resources (DERs)	Apply a "best-fit / least-cost" approach, or the traditional Utility Cost test
3	To achieve regulatory policy goals and/or societal benefits	Apply an Integrated Power System approach and Societal Cost test
4	Expenditures paid for by customers	No need for utilities or regulators to conduct a BCA

Source: US DOE 2017, *Modern Distribution Grid: Decision Guide,* Volume III, Section 3.4

BCA Framework for Grid Mod: US DOE (2 of 2)

DOE report offers three BCA approaches

BCA Approach	Purpose of Expenditure
Least-cost, best-fit	• Traditional distribution expenditures (e.g., replace aging infrastructure) • Core, foundational, GM platform components (e.g., SCADA, OMS, GIS)
Utility Cost test	• Non-core, modular components related to enhancing reliability and operational efficiency (e.g., AMI, VVO)
Integrated power system & Societal Cost test	• Non-core, modular components related to enhancing reliability and operational efficiency (e.g., AMI, VVO) • Components to achieve regulatory goals and/or societal benefits (e.g., to integrate DERs and enable markets)

Source: US DOE 2017, *Modern Distribution Grid: Decision Guide,* Volume III, Section 3.4

BCA Principles

Principle	NSPM	DOE	NYPSC
Assess projects comparably with traditional resources or technologies	✓	✓	Y
Account for state regulatory and policy goals	✓	✓	
Account for all relevant costs and benefits, including hard-to-monetize	✓	✓	
Ensure symmetry across relevant costs and benefits	✓	✓	
Apply full life-cycle analysis	✓	✓	✓
Apply incremental, forward-looking analysis	✓	✓	
Ensure transparency	✓	✓	✓
Avoid combining or conflating different costs and benefits			✓
Assess bundles and portfolios instead of separate measures	✓	✓	
Address locational and temporal values		✓	✓

Sources: National Efficiency Screening Project, *National Standard Practice Manual,* 2017;
US DOE, *Modern Distribution Grid: Decision Guide,* Volume III, 2017;
New York Public Service Commission, *Order Establishing the Benefit-Cost Framework*, 2016.

Terminology: BCA versus Business Case

- The term "benefit-cost analysis" typically refers to an approach that puts all costs and benefits into monetary values.
  - If benefits exceed costs, the investment is deemed to be cost-effective.
- The term "business case" typically refers to an approach that is broader and more flexible than a BCA.
  - A business case allows utilities to account for impacts that are not monetized.
  - Some business case approaches monetize all costs and benefits, but then leave flexibility for considering qualitative factors.
  - Other business case approaches include little monetization of the benefits, relying almost entirely on qualitative grounds for justifying the investment.
- Regardless of what the approach is called:
  - Monetary values should be used as much as possible.
  - Qualitative impacts should be fully documented and accounted for.

Review of Recent Grid Modernization Plans

Review of 21 Recent Grid Mod Plans

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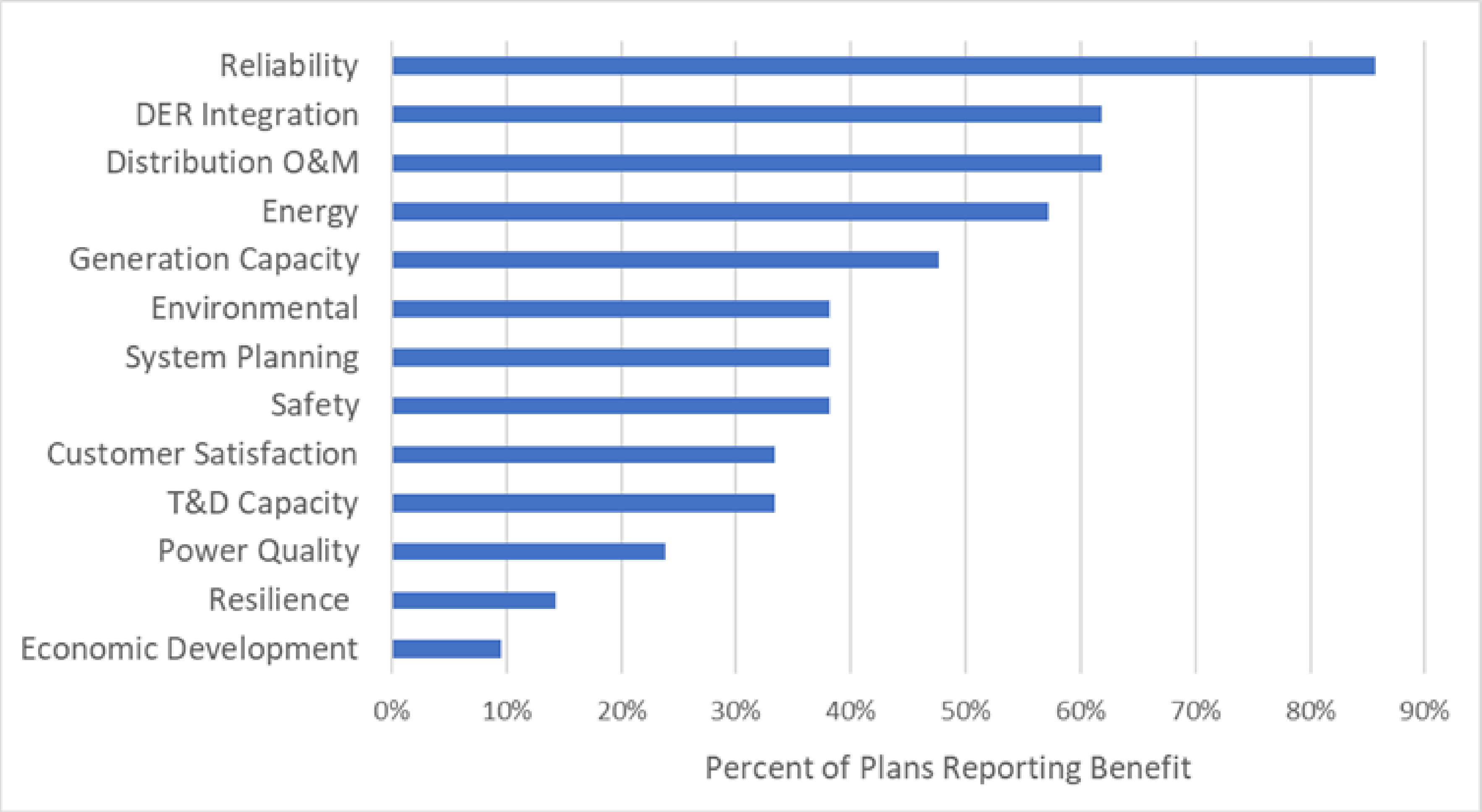
Utility	State	Year	Utility	State	Year
National Grid	NY	2016	**DTE Energy**	MI	2017
NYSEG & RGE	NY	2016	**APS**	AZ	2016
Unitil	MA	2015	**PSE&G**	NJ	2018
National Grid	MA	2016	**LGE**	KY	2018
Eversource	MA	2015	**Consumers Energy**	MT	2017
Public Service Co.	CO	2016	**Central Hudson G&E**	NY	2018
SDGE	CA	2016	**Hawaiian Electric Cos**	HI	2017
Xcel	MN	2017	**Southern CA Edison**	CA	2016
FirstEnergy	OH	2017	**CT Light & Power**	CT	2010
Vectren	IN	2017	**Entergy**	AR	2016
National Grid	RI	2018			

Sources: See Lawrence Berkeley National Laboratory, *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, Draft, February 2019.

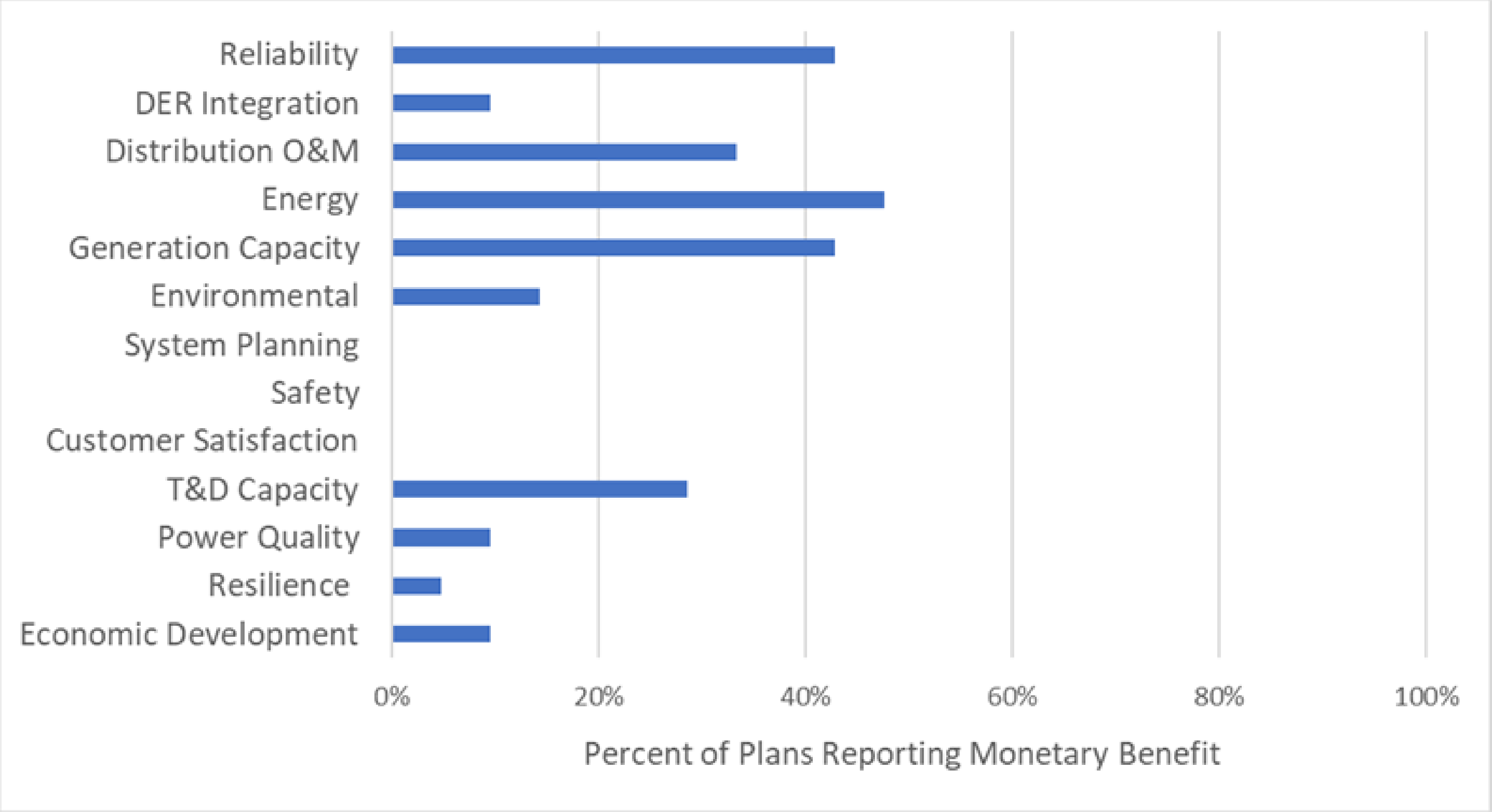
General Themes from Grid Mod Plans

- Few plans explicitly identify which cost-effectiveness test was used.
- Few plans explicitly identify which discount rate was used.
- Few plans articulate a methodology to account for the interdependencies of grid modernization components.
- Few plans articulate a methodology to account for qualitative benefits.
- Few plans include a robust definition of grid modernization metrics and how they will be used to monitor grid modernization benefits over time.
- Few plans provide both a clear overarching rationale for the investment and an explanation of how components will help meet overall goals.
- Few plans, if any, address customer equity issues directly.

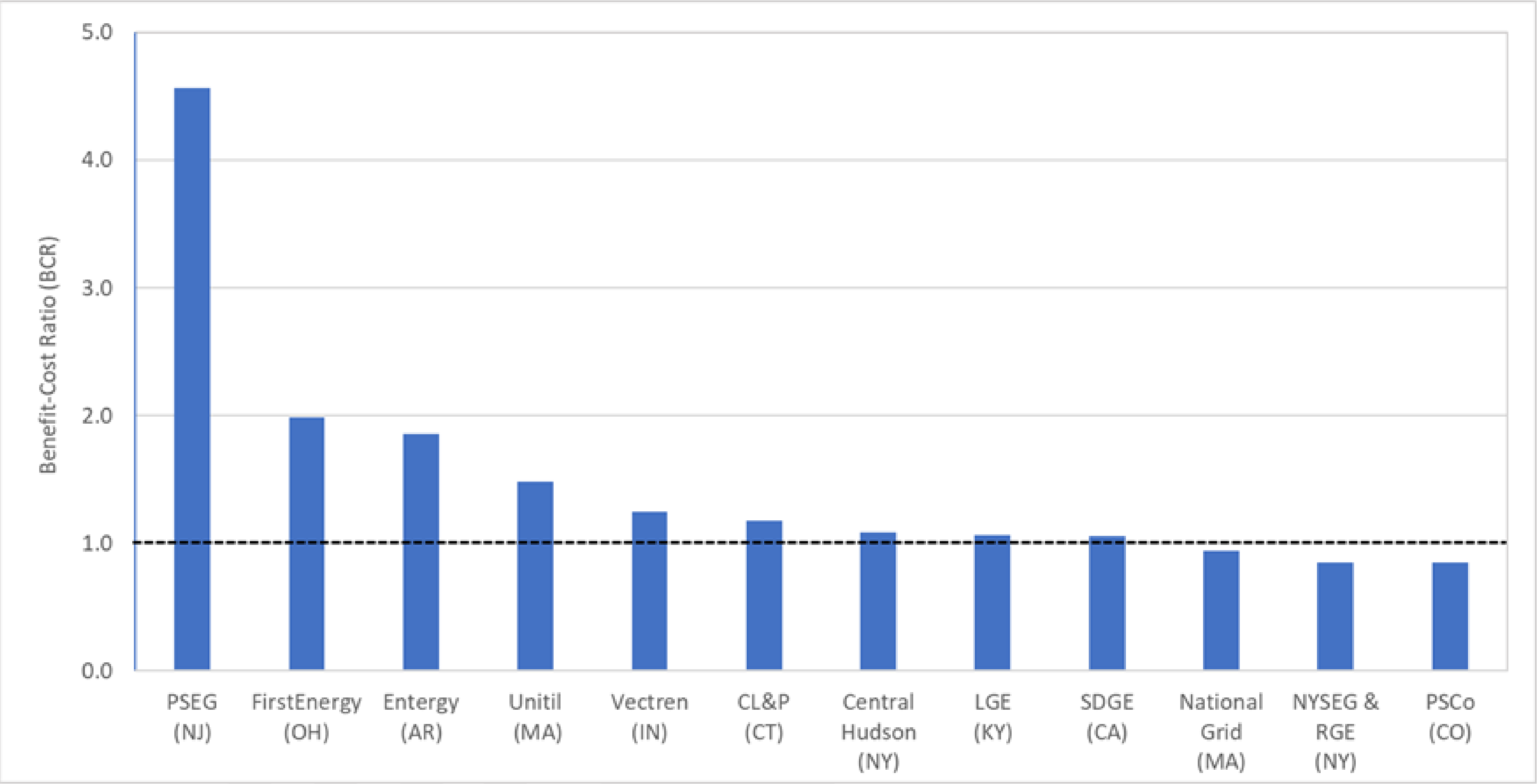
Type and Frequency of Claimed Benefits



Type and Frequency of Monetized Benefits



Grid Modernization Benefit-Cost Ratios



How to Address Key Grid Modernization BCA Challenges

Grid Mod BCA: Key Challenges

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- Documenting the purpose of each grid modernization component
- Choosing BCA framework or test
- Choosing a discount rate
- Accounting for interactive effects
- Accounting for qualitative benefits
- Addressing customer equity
  - Some grid modernization components might not reach/serve all customers
  - Some customers might not value some of the grid modernization benefits
- Ensuring net benefits for customers

Documenting the purpose of each grid modernization component (1 of 2)

- Documenting the purpose of each grid modernization component has several important implications for BCA:
  - Can help justify whether a least-cost, best-fit approach is warranted
  - Can help justify whether and how components are consistent with state regulatory directives and goals
- Document whether component plays a core, platform role:
  - Necessary to support distribution services in general
  - As opposed to modular, or optional, components offering distinct services
- Document whether component is a traditional expenditure:
  - Replacing aging infrastructure, interconnecting new customers, etc.
  - As opposed to an expenditure to support regulatory goals

Documenting the purpose of each grid modernization component (2 of 2)

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Principle	Objective	Capabilities	Functions	Technology
Provide customers information they need to make educated utility choices	Customer Enablement - Example Metric: Provide online customer access to relevant & timely information by 2020 for small business & residential customers	Transparency Confidentiality & Privacy	Customer Information Sharing Distribution Information Sharing Market Information Sharing Customer Information Management	Customer Portal Customer analytic tools Greenbutton Time interval metering Meter Data Management System Customer Info System Data Warehouse Meter communications

Source: U.S. Department of Energy, *DSPx Phase 2 Decision Process & Taxonomy Update*, slide deck, Draft, January 19, 2019.

Choosing a BCA Test

- Articulate the BCA test (or framework) upfront
- Apply the least-cost, best-fit framework where warranted
  - Traditional expenditures: replacing aging infrastructure, interconnecting new customers, or maintaining reliability
  - Platform components: necessary to support other, modular components
  - The validity of this test rests upon justification of the type of expenditure
- Apply multiple cost-effectiveness tests
  - Utility Cost test: best indication of impacts on customer bills
  - Regulatory test: best indication of achieving regulatory goals
- Apply both approaches as a check
  - For components where the least-cost, best-fit approach is used, apply the Utility Cost test to check the impact on costs.

Choosing a Discount Rate

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- The discount rate reflects a particular "time preference."
  - The relative importance of short- versus long-term impacts
- Examples of discount rates

Investor-owned utility WACC:	5%-8%
Publicly-owned utility WACC:	3%-5%
Utility customers:	Varies widely
Low risk:	0%-3%
Societal:	<0%-3%

- Utility weighted average cost of capital (WACC) is widely used in BCA for grid modernization and other purposes.

Limitations of Utility WACC as a Discount Rate

The goal of BCAs for unregulated businesses is different from the goal of BCAs in regulatory settings:

- For unregulated businesses, the goal of BCA is to maximize shareholder value.
  - Investors' time preference is driven entirely by investors' opportunity cost and risk, and the WACC reflects both of those.
- For regulated utilities, the goal of BCA is fundamentally different:
  - The goal is to provide safe, reliable, low-cost power to customers and meet policy goals.
  - The goal is not to maximize shareholder value.
- Since the goal for a regulated utility is different, the time preference is also different. Thus, the choice of a discount rate should take this into consideration.

Discount Rate Considerations

- The choice of discount rate is a policy decision.
- The discount rate should reflect the time preference chosen by regulators on behalf of all customers, i.e., the regulatory perspective.
- The regulatory perspective should account for many factors:
  - low-cost, safe, reliable service; intergenerational equity; other regulatory policy goals
- The regulatory perspective suggests a greater emphasis on long-term impacts than what is reflected in the WACC.
  - Which implies a lower discount rate
- Grid mod plans can use sensitivities to consider different discount rates.
  - Use the utility WACC as a high case
  - Use a low-risk or societal discount rate as a low case

Accounting for Interdependences

- Apply the least-cost, best-fit framework where warranted
  - Platform components
  - The validity of this test rests upon justification of the type of expenditure.
- Apply BCA tests for every component in isolation
  - Utility Cost test
  - Regulatory test
- Apply BCA tests to several scenarios where components are bundled in different ways.
  - Just platform components
  - Layers of modular, application components on top of platform

Accounting for Interdependences: Example

	Scenario 1: Platform Components Only	Scenario 2: Platform Plus FLISR and VVO	Scenario 3: Scenario 2 Plus AMI and DERMS
Costs (Mil PV$)	24	28	32
Benefits (Mil PV$)	22	36	38
Net Benefits (Mil PV$)	-2	8	6
Benefit-Cost Ratio	0.9	1.3	1.2
Findings:	not cost-effective	cost-effective	potentially cost-effective

Scenario 3 has two potential interpretations:

- AMI and VVO are deemed cost-effective, because the portfolio is cost-effective.
- AMI and VVO are deemed not cost-effective, because they reduce the net benefits relative to scenario 2.

Accounting for Qualitative Benefits

- Put as many benefits as possible in monetary terms
- Apply the least-cost, best-fit framework where warranted
  - This approach does not require monetization of benefits
  - It requires only a minimization of costs, for the desired function/outcome
  - The validity of this test rests upon justification of the type of expenditure
- Establish metrics to assess benefits
  - Metrics do not need to be in monetary terms
- Use quantitative methods to address qualitative benefits:
  - use a point system to assign value to qualitative benefits
  - use a weighting system to assign priorities to qualitative benefits
  - assign proxy values for significant qualitative benefits
  - use multi-attribute decision-making techniques

Accounting for Qualitative Benefits: Example

	1. Platform Components Only	2. Platform Plus FLISR and DERMs	3. Scenario 2 Plus AMI and VVO
Monetary Impacts:	--	--	--
Costs (Mil PV$)	24	28	32
Benefits (Mil PV$)	22	36	38
Net Benefits (Mil PV$)	-2	8	6
Benefit-Cost Ratio	0.9	1.3	1.2
Qualitative Impacts:	--	--	--
Resilience	1	1	3
Customer choice& flexibility	1	2	3
Findings:	not cost-effective	cost-effective	cost-effective

Scenario 3 is deemed to be cost-effective because of the high value of qualitative benefits.

Addressing Customer Equity

- Fully document the purpose and role of each grid modernization component
  - Traditional
  - Platform
  - Least-cost, best-fit
- Articulate the beneficiaries of grid modernization components
  - Which customers
  - How many customers
  - Over what time period
- Prioritize the results of the Utility Cost test over other tests
  - Utility Cost test provides the best indication of impacts on customer bills
- Conduct a long-term bill impact analysis
  - Helps to put the grid modernization costs in context

Ensuring Net Benefits to Customers

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Regulators can use ratemaking and cost recovery approaches to help ensure that customers experience net benefits from grid modernization proposals.

- Limit the amount of grid modernization costs that the utility can recover to those proposed in the grid modernization plan
  - With allowance for contingency

- Limit the amount of grid modernization costs that the utility can recover to achievement of grid modernization benefits
  - Metrics can be used to assess achievement of benefits.

Summary: How to Address Key Challenges

Challenge	Potential Approaches
Documenting the purpose of each grid modernization component	• Specify a standard taxonomy for grid modernization • Define purpose and role of grid modernization components
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Contact Information

Synapse Energy Economics is a research and consulting firm specializing in technical analyses of energy, economic, and environmental topics. Since 1996 Synapse been a leader in providing rigorous analysis of the electric power and natural gas sectors for public interest and governmental clients.

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