Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments

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Outline of Presentation

- 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 plan BCAs
- How to address key challenges of grid modernization BCAs

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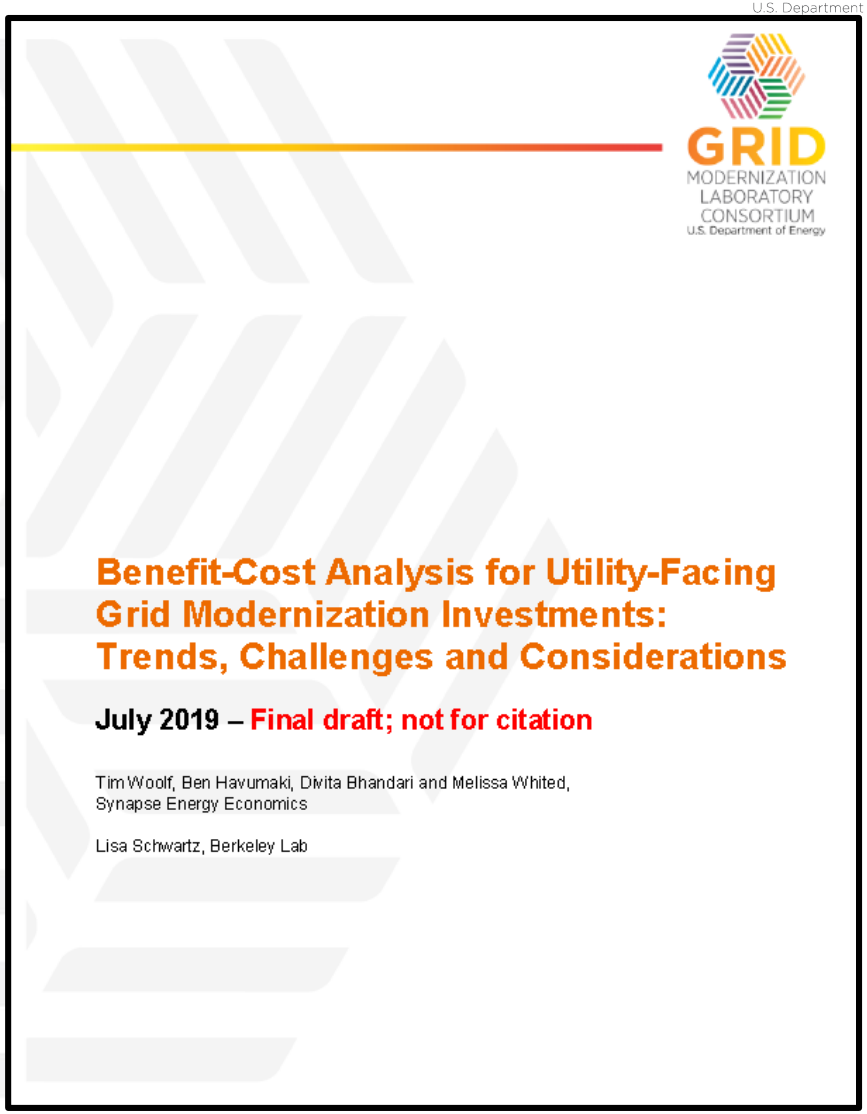

Utility-Facing
Grid Modernization Concepts

Utility Facing Versus Customer Facing

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Grid Modernization

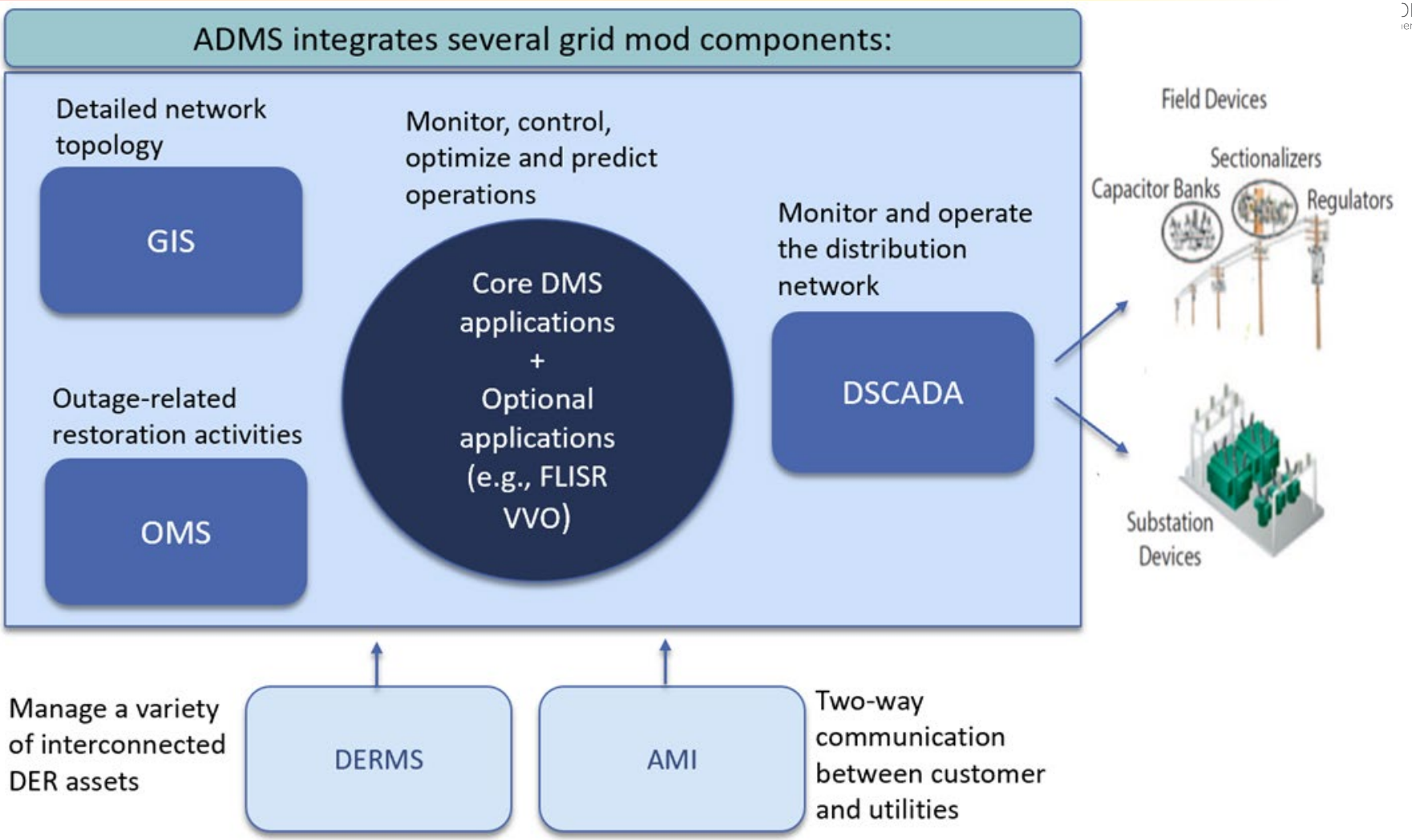
Utility-Facing

- 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, and 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

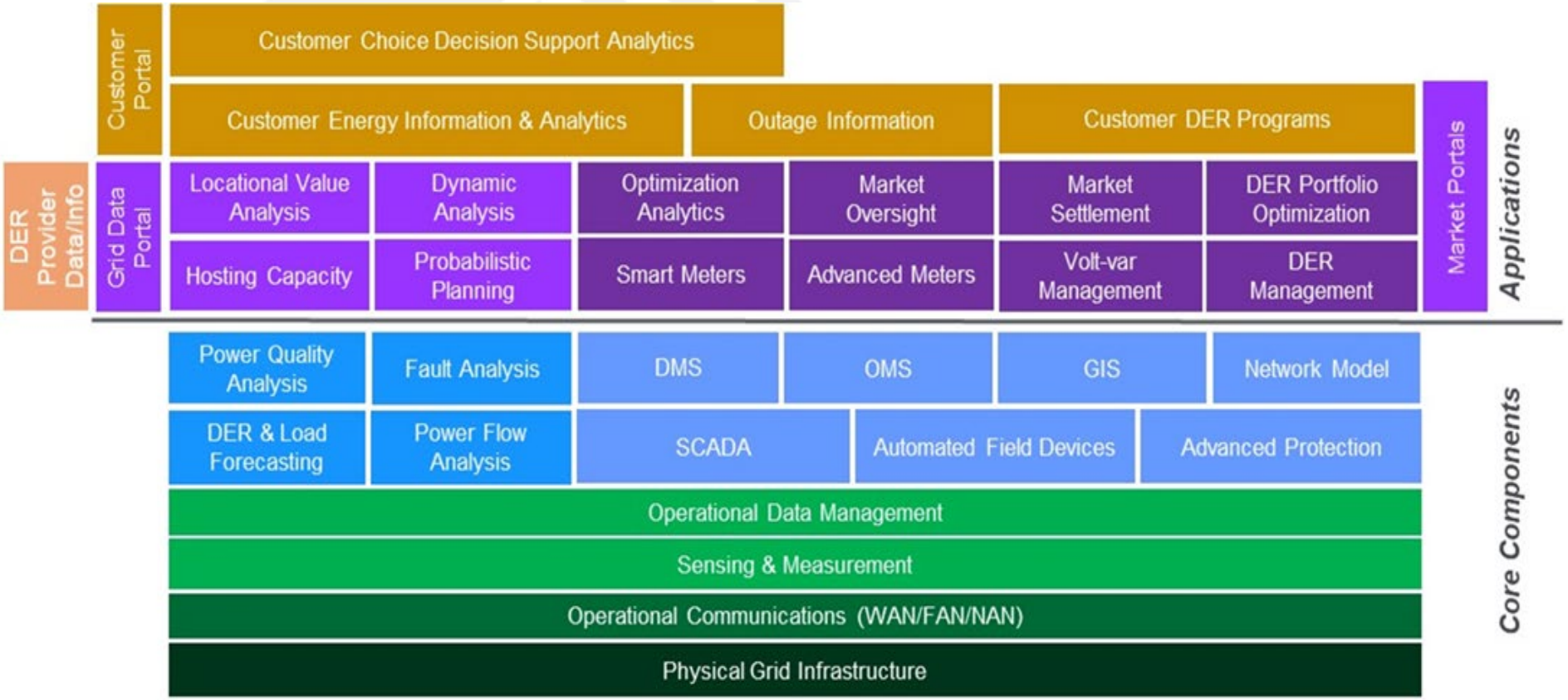
- Energy efficiency
- Demand response
- Distributed generation
- Storage
- Electric vehicles
- Advanced meters
- Third-party access
- Customer data
- Cybersecurity

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
   - Allows for focused review of proposal
   - Sometimes initiated by commission; sometimes by the utility
   - Utility often asks for some form of regulatory guidance or approval
   - Implications of regulatory guidance or approval vary by state
2. Utility seeking recovery of costs *after* spending
   - Typically in a rate case
   - Allows for retrospective prudence review
   - Allows for review in context of other utility 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 *before* spending

Examples of Benefits of Utility-Facing Grid Modernization

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Benefit	Utility System	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	✓	✓
Reduced environmental compliance costs	✓	✓
Environmental benefits		✓
Economic development benefits		✓

Examples of Costs for Utility-Facing Grid Modernization

Cost	Utility System	Society
Incremental capital costs for grid modernization equipment	✓	-
Incremental O&M costs for grid modernization equipment	✓	-
Incremental costs for T&D upgrades needed to support the grid modernization equipment	✓	-

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

Traditional BCA Tests for **Energy Efficiency**

- 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"
- Explains the 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 (Vol III)

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 (Vol IV)

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Draft DOE report recognizes four justifications for investments:

Justification	BCA Approach
Joint benefits: core platform investments that are needed to enable capabilities and functions	Least-cost, best-fit approach
Policy and standards compliance: utility investments that are needed to comply with policy goals and safety and reliability standards	Least-cost, best-fit approach
Net customer benefits: utility investments from which some or all customers receive net benefits in the form of bill savings	Standard benefit-cost analysis approach
Customer choice: investments triggered by customer interconnection, opt-in utility programs, and customer-driven reliability improvements, paid for by individual customers	No need for utilities or regulators to conduct a BCA

Source: US DOE 2019 forthcoming, *Modern Distribution Grid: Decision Guide,* Volume IV, Section 5.3

BCA Principles from Recent Sources

Principle	NSPM	DOE	NYPSC
Assess projects comparably with traditional resources or technologies	✓	✓	✓
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.

Review of Recent Grid Modernization Plans

Review of BCAs from 21 Recent Grid Mod Plans

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Utility	State	Year	Utility	State	Year
National Grid	NY	2016	**DTE Energy**	MI	2018
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	2018
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

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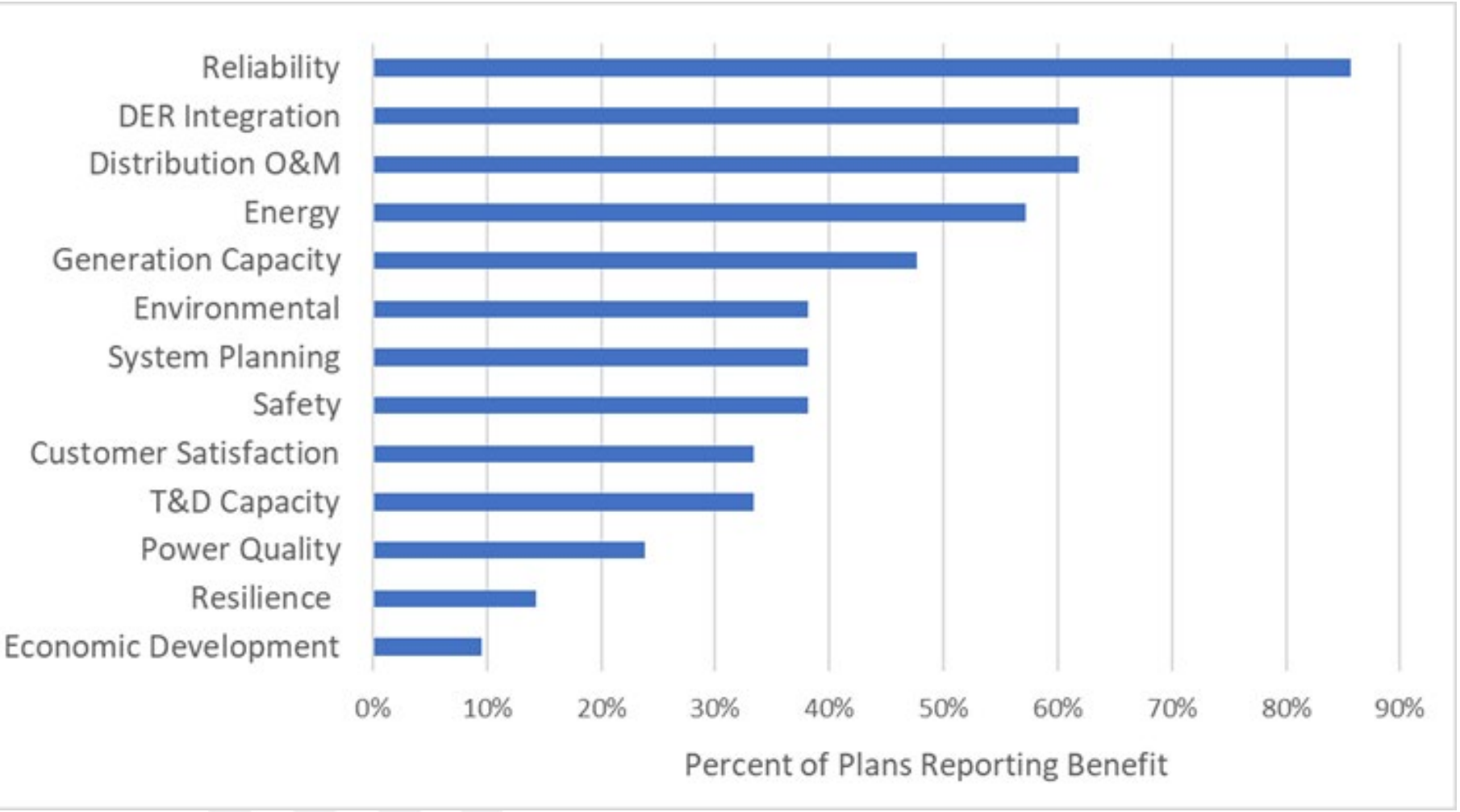
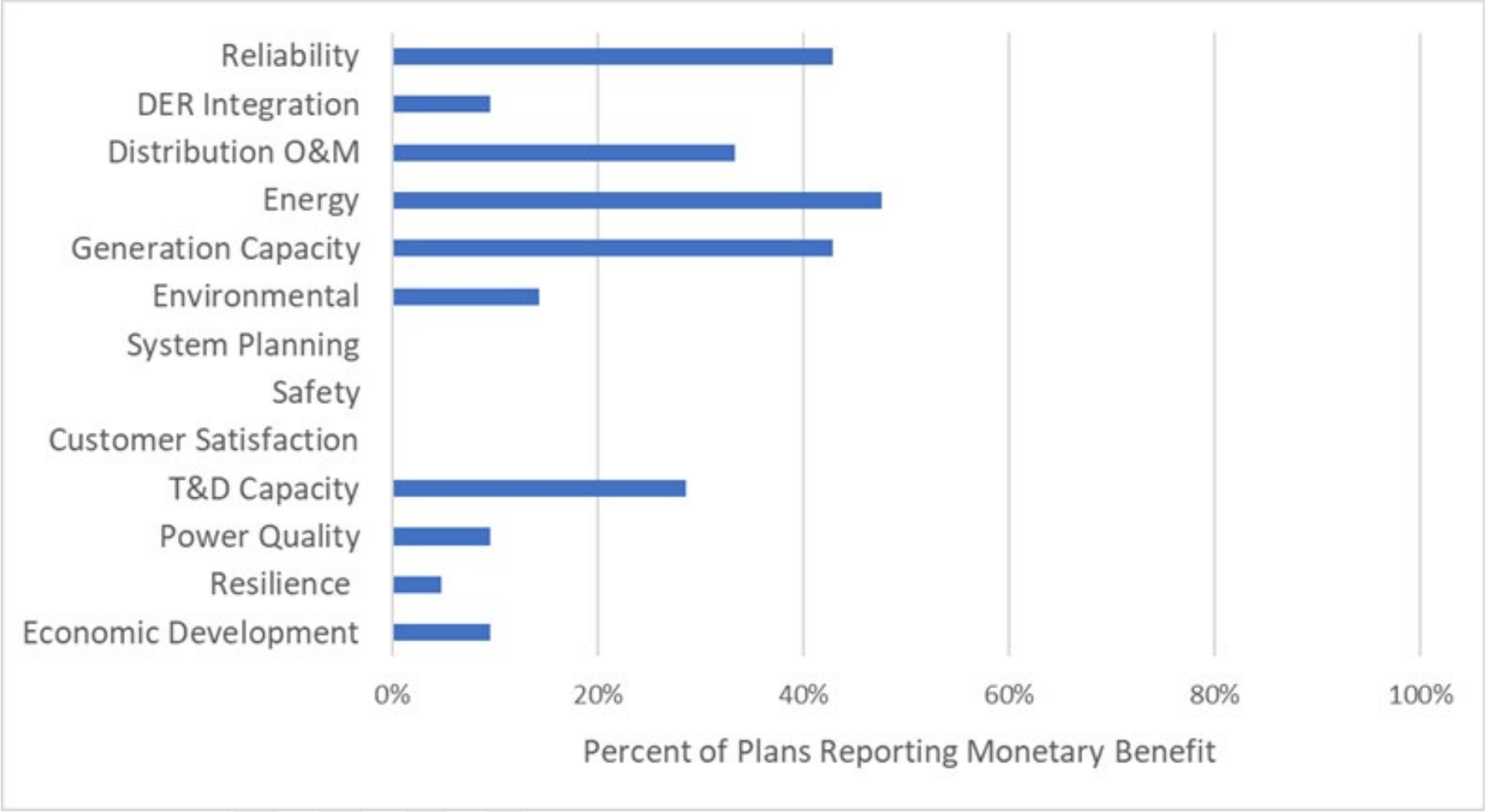
Key items that were lacking in many plans:

- An overarching rationale for grid modernization investments and an explanation of how individual components will help meet overall goals
- Identification of which cost-effectiveness test was used for the BCA
- Identification of which discount rate was used to determine present values
- Methodologies to account for the interdependencies of grid modernization components
- Methodologies to account for unmonetized benefits of grid modernization components
- Robust definitions of grid modernization metrics and how they will be used to monitor grid modernization costs and benefits over time
- Methodologies or discussions of how to address customer equity issues

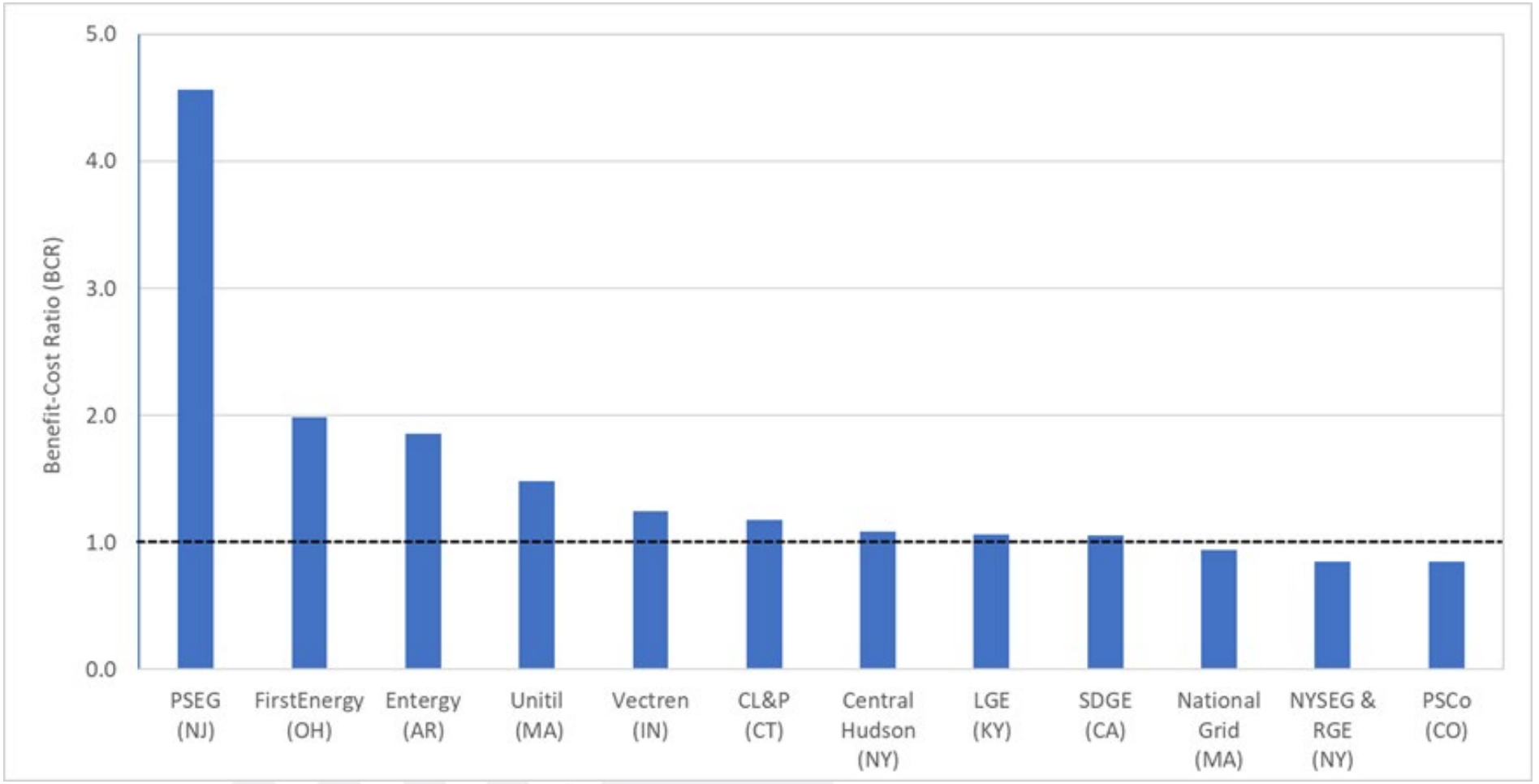
Type and Frequency of Claimed Benefits



Type and Frequency of Monetized Benefits



Grid Modernization Benefit-Cost Ratios



How to Address Key Grid Modernization BCA Challenges

Grid Mod BCA: Key Challenges

- Documenting the purpose of each grid modernization component
- Choosing BCA framework or test
- Choosing the discount rate(s)
- Accounting for interactive effects
- Accounting for benefits that are hard to quantify or monetize
- Addressing uncertainty
- Putting the BCA results in context
- Encouraging follow-through

Documenting the purpose of each grid modernization component

Documenting the purpose of each grid modernization component has several important implications for BCA:

- Document whether component is a traditional expenditure:
  - Replacing aging infrastructure, interconnecting new customers, etc.
- Document whether component plays a core, platform role.
  - Can help justify whether a least-cost, best-fit approach is warranted.
- Document whether component is modular, or optional.
  - Can help justify which BCA approach to use.
- Document whether and how components are consistent with state regulatory directives and goals.

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.

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
  - For core, 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 core, platform components
  - Layers of modular, application components on top of platform components

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 non-Monetized Benefits

- Put as many benefits as possible in monetary terms
- Define benefits in such a way that they can be monetized
- Provide as much quantitative data as possible
- 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 non-monetized benefits:
  - use a point system to assign value to non-monetized benefits
  - use a weighting system to assign priorities to non-monetized benefits
  - assign proxy values for significant non-monetized benefits
  - use multi-attribute decision-making techniques

Accounting for Non-Monetized Benefits: Example

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	Scenario 1: Platform Components Only	Scenario 2: Platform Plus FLISR and VVO	Scenario 3: Scenario 2 Plus AMI and DERMS
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
Non-Monetized Benefits:	--	--	--
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 non-monetized benefits.

Approaches for Additional Challenges

- Addressing uncertainty
  - Use contingency costs
  - Use scenario and sensitivity analyses
  - Use probabilistic and expected value modeling
- Putting BCA results in context
  - Assess the long-term bill impacts on typical customers
  - Consider prioritizing the results of the Utility Cost test over other tests. The Utility Cost test may provide the best indication of impacts on total customer costs.
- Encouraging follow-through
  - Establish metrics to monitor costs and benefits over time
  - Metrics can also be used as performance incentive mechanisms

Summary: How to Address Key Challenges

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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(s)	• 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 benefits that are hard to quantify or monetize	• Use the least-cost, best-fit approach where warranted • Establish metrics to assess the extent of benefits • Apply methodologies to make unmonetized benefits transparent
Addressing uncertainty	• Use approaches that include contingency costs, scenario and sensitivity analyses, and probabilistic and expected value modeling
Putting BCA results in context	• Assess long-term bill impacts
Encouraging follow-through	• Establish metrics to monitor achievement of benefits

Contact Information

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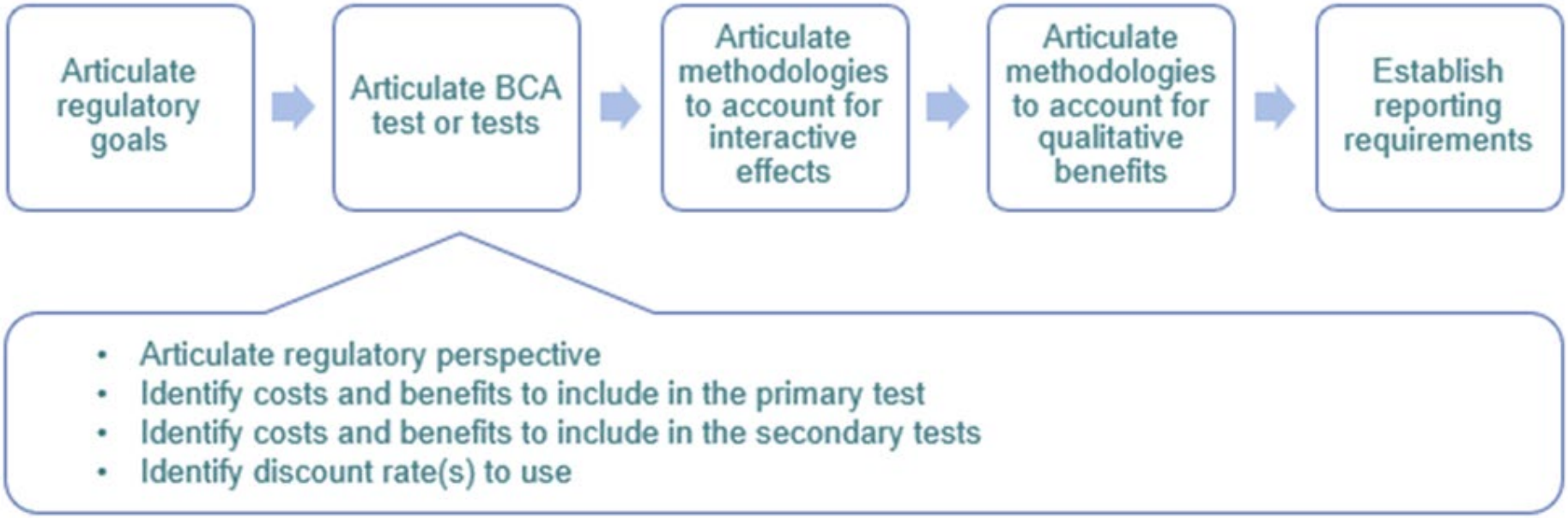
Appendix

Public Utility Commission Guidance - Summary



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 non-monetized 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.
  - Non-monetized impacts should be fully documented and accounted for.

Documenting the purpose of each grid modernization component

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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 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.