Economic Assessment of Grid Modernization Plans

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Training Webinars on Electricity System Planning
for New England Conference of Public Utilities Commissioners
May 19, 2022

This presentation was funded by the U.S. Department of Energy's Grid Modernization Laboratory Consortium.

Overview

- Review of several utility Grid Mod Plans
- General guidance on economic evaluation of Grid Mod Plans
- Benefit-cost analysis (BCA) versus least-cost/best-fit (LCBF)
- Accounting for interdependencies between grid mod components
- Accounting for hard to quantify benefits
- Accounting for customer equity
- Based on two recent studies
  - T. Woolf, B. Havumaki, D. Bhandari, M. Whited and L. Schwartz, *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments: Trends, Challenges, and Considerations*, Berkeley Lab, 2021.
  - Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, prepared by Synapse Energy Economics, 2022. (Docket No. E002/M-21-814, available through eDockets)

Review of Benefit-Cost Analyses in Grid Modernization Plans

Review of BCAs in 21 Grid Mod Plans

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			

Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

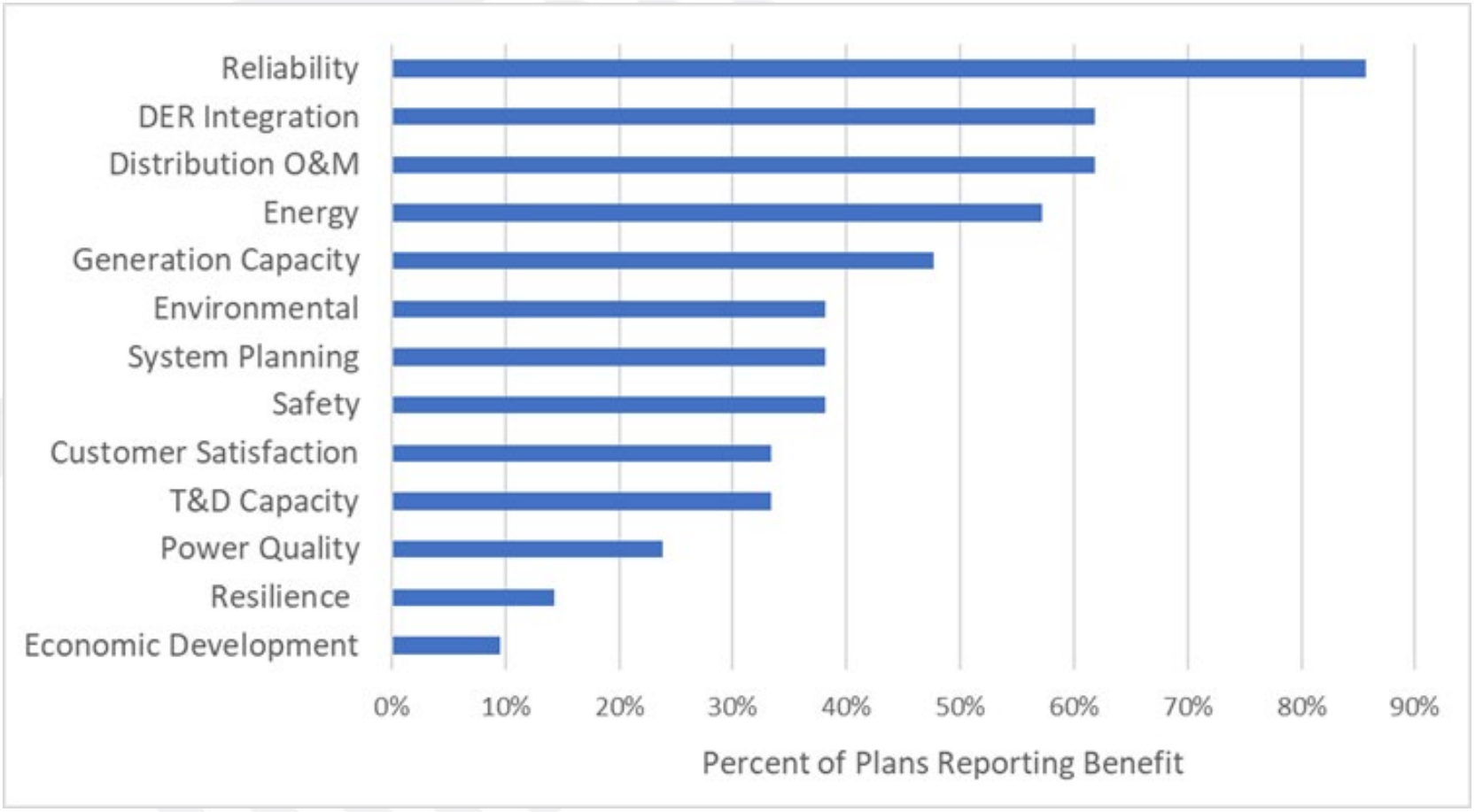
Review of Grid Mod Plans: Themes

Key items that were generally lacking:

- 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 and discussions for addressing customer equity issues

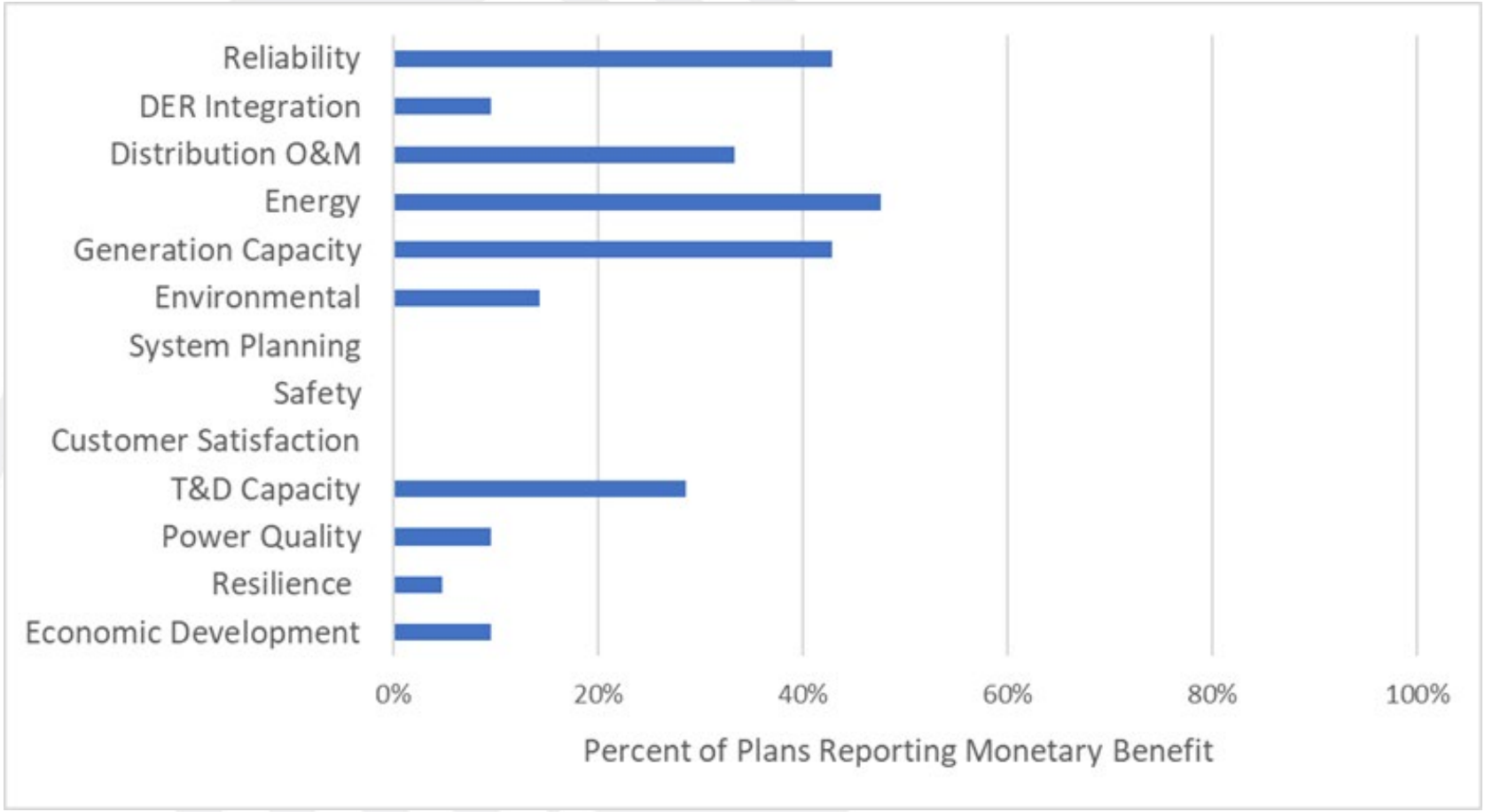
Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

Type and Frequency of Claimed Benefits



Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

Type and Frequency of Monetized Benefits



Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

Economic Evaluation of Grid Modernization Plans

Grid Mod Regulatory Contexts

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Utility seeking review of costs *before* spending

- Typically, in a case dedicated to review of proposed investments
- Allows for focused review of proposal (outside rate case)
- 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

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 Grid Mod Benefits

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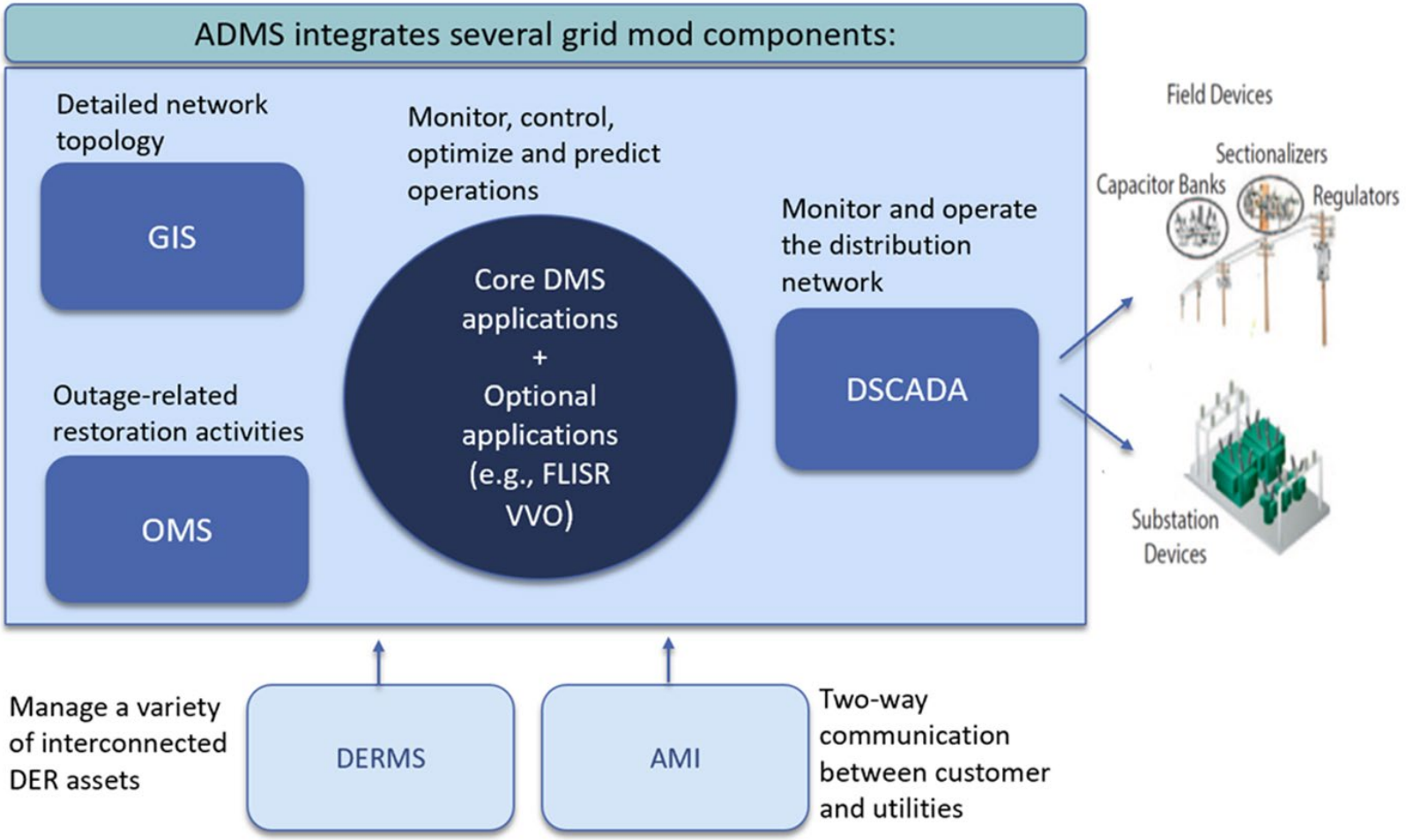
Benefit	Utility System	Society
Reduced O&M costs	✓	✓
Reduced generation capacity costs	✓	✓
Reduced energy costs	✓	✓
Reduced T&D costs and losses	✓	✓
Reduced ancillary services costs	✓	✓
Increased system reliability	✓	✓
Increased safety	✓	✓
Increased resilience	✓	✓
Increased distributed energy resource (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 Grid Mod Costs

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	✓	-
Program administration costs	✓	-

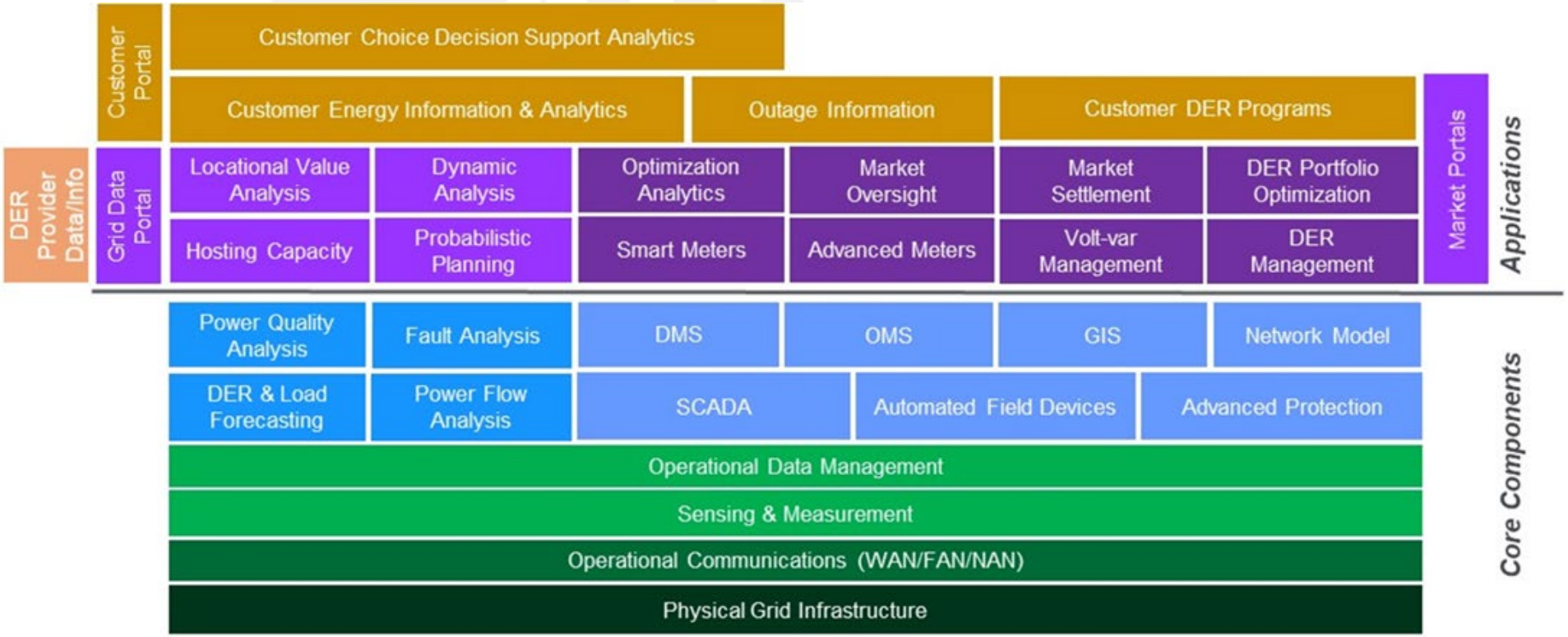
- Grid modernization costs are typically recovered from all customers.
  - But the benefits might not be experienced by all customers.
- Grid modernization costs are relatively easy to quantify and monetize.
  - But the benefits are sometimes hard to quantify and monetize.

Interdependence of Components



Source: Adapted from World Bank, *Practical Guidance for Defining a Smart Grid Modernization Strategy: The Case of Distribution*, 2017.
For definition of terms, see glossary in US DOE, *Modern Distribution Grid: Strategy & Implementation Guidebook*, 2020

Core Components Versus Applications



Source: US DOE, *Modern Distribution Grid: Strategy & Implementation Guidebook*, 2020, page 59.

Principles for Grid Mod Economic Analysis

1. Compare consistently with traditional resources or technologies
2. Clearly account for state regulatory and policy goals
3. Account for all relevant costs and benefits, including those difficult to monetize
4. Consider interdependencies between components where feasible
5. Consider customer equity issues
6. Provide symmetry across relevant costs and benefits
7. Apply a full life-cycle analysis
8. Provide a sufficient incremental and forward-looking view
9. Ensure transparency
10. Avoid combining or conflating different costs and benefits
11. Address locational and temporal values

Source: Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, prepared by Synapse Energy Economics, Attachment to Department of Commerce Letter. Docket No. E002/M-21-814, February 9, 2022

Articulate Grid Modernization Goals

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Sample Goal	Sample Objectives and Targets	Sample Metric and Reporting
Accommodate higher capacities of DERs	DER capacity 50% of minimum recorded load on 25% of circuits by 2025	Annual report by circuit: • DER capacity • Minimum recorded load
	DER capacity 100% of minimum recorded load on 50% of circuits by 2030	
	DER capacity 100% of maximum recorded load on 50% of circuits by 2035	Annual report by circuit: • DER capacity • Maximum recorded load
Avoid interconnection delays	Interconnection decisions rendered on systems under 10 kW within 5 business days on circuits with available distributed energy resource capacity.	Annual reports: • Interconnection requests by size • Date of each request • Date on which decision was communicated for each request
	Interconnection decisions rendered on systems between 10 and 100 kW within 30 days on circuits with available distributed energy resource capacity	
	Interconnection decisions rendered on systems over 100 kW within 90 days	

Source: Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, Attachment to Department of Commerce Letter. Docket No. E002/M-21-814, February 9, 2022

Example performance metrics

Example benefit	Example performance metrics
DER deployment	Number of DER installations
Customer satisfaction	Customer ratings, customer engagement metrics
Reliability	System-wide or targeted SAIDI, SAIFI, CAIDI, CAIFI
Resilience	Restoration time after extreme weather events
Safety	Number of safety events, injuries, deaths
Network and data access	Interconnection times, data access times, developer satisfaction
Retail competition	Number of customers choosing a competitive option

Performance metrics can be used to indicate the extent to which purported benefits will be achieved.

Benefit-Cost Analysis versus Least-Cost/Best-Fit Analysis

Description of BCA and LCBF

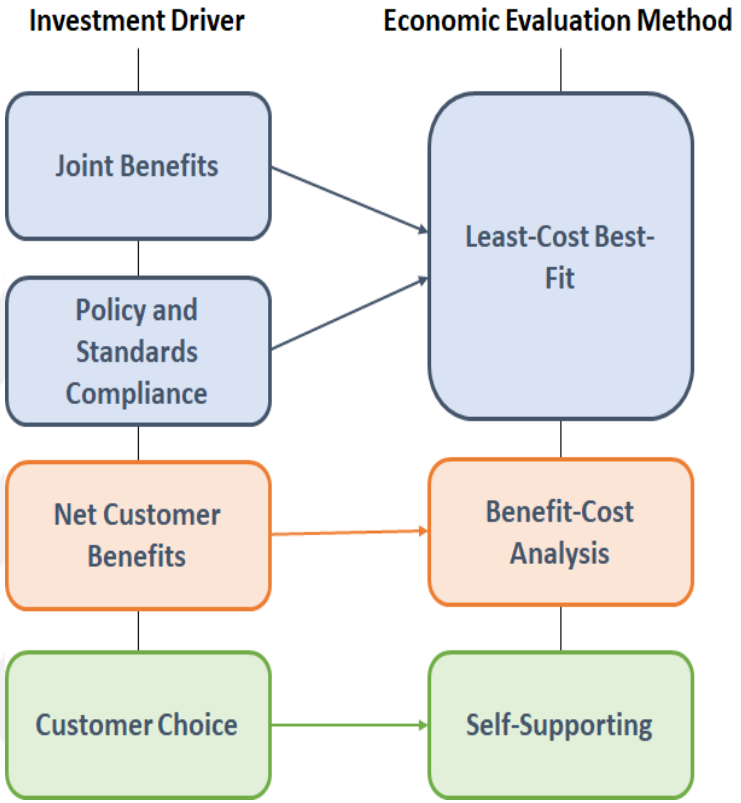
- Least-Cost/Best-Fit
  - For investments where the "need" has been established
    - Ex: A new distribution line is needed to provide service to a new residential development.
  - Different options might be considered for how to meet the need.
    - Ex. Different paths, different combinations of transformers, substations, etc.
  - LCBF is used to determine the option that meets the need at the lowest cost
  - Does not necessarily require quantifying or monetizing the benefits
- Benefit-Cost Analysis
  - For determining whether to make an investment
  - BCA used to determine whether the investment will result in net benefits
  - Typically includes monetizing, or at least quantifying, all costs and benefits
- The line between these two approaches is not always clear.

BCA Versus Least-Cost/Best-Fit

	Need	Purpose	Application	Costs	Benefits
Least-Cost/ Best-Fit	Need for the investment has been established	To identify the investment that meets the need at lowest cost	Which option is the lowest-cost way to meet the need?	Included Typically includes only utility system costs	Not Required Benefits are not necessarily accounted for; presumed to be worth the costs
BCA	Need for the investment has not been established	To determine whether to make the proposed investment	Do the benefits of the investment outweigh the costs?	Included Extent of costs depends upon BCA test chosen	Included Extent of benefits depends upon BCA test chosen

Economic Evaluation Options (from DOE)

- **Joint and interdependent benefits** — core platform investments needed to enable new capabilities and functions
- **Standards compliance and policy mandates** — utility investments needed to comply with safety and reliability standards or to meet policy mandates
- **Net customer benefits** — utility investments from which some or all customers receive net benefits in the form of bill savings
- **Customer choice** — customer-driven projects paid for by individual customers



Source: US DOE, *Modern Distribution Grid: Strategy & Implementation Guidebook*, 2020, page 113.

BCA Versus Least-Cost/Best-Fit

- The main difference
  - LCBF presumes that the utility investment is needed.
    - Therefore, the benefits of the investment are not necessarily monetized.
  - BCA is used to justify the investment.
    - Benefits are monetized to demonstrate that the investment will have net benefits.
- LCBF has been used for distribution planning for many years.
  - Because it was applied to investments that were clearly needed to maintain reliability
  - Ex: A new substation needs to be upgraded to serve an increasing customer demand.
    - What is the least-cost technology for upgrading the substation?
- Now, there are more options to consider.
  - Ex: A non-wires alternative could be implemented instead of a substation upgrade
    - A BCA should be conducted to determine which has greater net benefits.

Is There a "Need" for the Investment?

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- For grid mod investments, the need is often not clear
  - Is an automated distribution management system (ADMS) necessary?
  - Is advanced metering infrastructure (AMI) necessary?
  - Is Volt-Var Optimization (VVO) necessary?
  - Grid modernization is sometimes described as necessary, but some components might not be, and some components might have costs that exceed the benefits.
- A better question to ask:
  - Will the grid mod investment result in net benefits?
  - This is the key question for Commissions, Commission staff, and consumer advocates
- This question can be answered only by a BCA
  - Therefore, BCA should be given priority over LCBF for grid mod evaluations
- BCAs provide value even if the need for grid mod investment seems clear
  - The BCA information on benefits is helpful (a) at the time of the investment decision, and (b) after the investment has been made, to monitor performance over time.

When Should BCA Be Used Instead of LCBF?

Reasons Not to Conduct a BCA	Responses
Some benefits are too hard to monetize.	There are ways to account for benefits without monetizing them.
Some grid mod components are necessary to support other elements, and it is difficult to isolate, quantify, or monetize the benefits.	BCAs can be used to assess interdependencies between components.
Some grid mod components work jointly with other components, and it is difficult to isolate, quantify, or monetize the benefits.	BCAs can be used to assess interdependencies between components.
A BCA might be expensive and burdensome.	This reason is not sufficient to justify LCBF, given the utility is proposing to spend millions of dollars on grid modernization.

Answer: BCA should be the default approach. An LCBF may be appropriate in certain situations.

BCA Provides More Information than LCBF

BCAs provide more transparency, even if all the benefits are not quantified.

Costs / Benefits (mil PV$)	Type of Cost or Benefit	LCBF	BCA #1	BCA #2
Costs	Capital, O&M, administration	20	20	20
Benefits monetized	Energy, capacity, O&M, T&D	?	18	12
Benefits not monetized	Reliability & resilience	?	?	?
Net benefits	---	?	-2	-8
Benefit-cost ratio	---	?	0.9	0.6

Result #1: This component might be deemed to be cost-effective because the reliability and resilience benefits are worth the $2 million net cost.
Result #2: This component might be deemed to be not cost-effective because the reliability and resilience benefits are not worth the $8 million net cost.

Accounting for Interdependencies, Hard to Quantify Benefits, and Customer Equity

Accounting for Interdependences

- Apply LCBF if necessary.
  - The use of LCBF must be justified in the Grid Mod Plan.
- Apply BCA tests for each component in isolation.
  - Using a BCA test appropriate for your state
- Apply BCA to several scenarios where components are bundled in different ways.
  - Start with just platform components
  - Add layers of application components on top of platform components
  - Assess how the BCA results change with different combinations of 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 DERMS are deemed cost-effective, because the portfolio is cost-effective.
- AMI and DERMS 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.
    - Ex: For reliability use SAIDI, SAIFI, MAIFI, CAIDI values
- Provide as much qualitative description as possible.
  - Can be used to inform the economic decision
- Establish metrics to report benefits.
  - Monitor metrics (benefits) over time
- Use quantitative methods to address non-monetized benefits.
  - Assign proxy values for significant non-monetized benefits
  - Use a point system to assign value to non-monetized benefits

Source: Woolf et al., *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments*, prepared for Berkeley Lab, 2021.

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.

Addressing Customer Equity

- Fully document the purpose and role of each grid mod component
  - Traditional, Platform, Application
- Articulate the beneficiaries of grid modernization components
  - Which types of customers?
  - How many of those types of customers?
  - Over what time period?
- Consider results of the Utility Cost test
  - Provides the best indication of impacts on customer bills
- Present estimates of long-term customer bill impacts
  - Helps to put the grid modernization costs in context
- Consider implications for target populations

Ensuring Net Benefits to Customers

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

- Limit the amount of grid modernization costs that the utility can recover to the costs proposed in the grid modernization plan.
  - Utilities required to absorb cost over-runs
  - With allowances for contingencies
- Limit the amount of grid modernization costs that the utility can recover over time based on achievement of purported grid mod benefits.
  - Require utilities to absorb a portion of costs if benefits are not achieved
  - Use metrics to assess achievement of benefits
  - Provide allowances for contingencies

Questions Public Utility Commissions Can Ask (1)

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Initial Grid Mod Plan filing requirements:

- Are grid mod goals clearly articulated, and is their relationship to policy goals clear?
  - Are there metrics with concrete measurable outcomes?
- Does the Grid Mod Plan demonstrate consistency with the utility's distribution, transmission, and resource plans?
- Are the roles and relationships of each grid mod component identified?
- Is the scope of the economic analysis identified?
  - Utility Cost test, Societal Cost test, Jurisdiction Specific test?
- Does the plan indicate the cost-effectiveness approach used — BCA or LCBF?
  - Is any use of LCBF justified?
- Is there a thorough evaluation of alternatives to utility distribution investments?
- Does the plan clearly document how non-monetary impacts are accounted for?
- Does the plan clearly document how interrelated impacts are accounted for?
- Does the plan clearly present results of all economic analyses?

Source: Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, 2022.

Questions Public Utility Commissions Can Ask (2)

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Ongoing annual Grid Mod Plan reporting requirements:

- Does the plan specify what updates will be filed to project scope, functions, or outcomes?
- How will the utility regularly report on progress on implementation and integration of grid mod components?
- How and when will the utility provide updates on capital costs and operating expenses?
  - Total to date, percent of total budgeted costs, potential budget over-runs
- How will the utility document performance of grid mod projects?
  - Using actual data from previous year
  - Using all metrics established in Grid Mod Plan
  - Comparing actual performance to metrics established in the Grid Mod Plan
- Did the utility include a well-defined action plan?
  - To describe whether and how the next year's grid mod implementation might be modified to account for information from the previous year

Source: Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, 2022.

Resources for more information

US DOE Grid Modernization Laboratory Consortium website: https://www.energy.gov/gmi/grid-modernization-lab-consortium

US DOE, *Modern Distribution Grid: Strategy & Implementation Guidebook*, Volume IV, 2020

US DOE Grid Mod Laboratory Consortium, *A Valuation Framework for Informing Grid Modernization Decisions: Guidelines on the Principles and Process of Valuing Grid Services and Technologies*, prepared for the National Association of Regulatory Utility Commissioners, 2019

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

T. Woolf, B. Havumaki, D. Bhandari, M. Whited and L. Schwartz, *Benefit-Cost Analysis for Utility-Facing Grid Modernization Investments: Trends, Challenges and Considerations*, Berkeley Lab, 2021

Minnesota Department of Commerce, *Review and Assessment of Grid Modernization Plans: Guidance for Regulators, Utilities, and Other Stakeholders*, prepared by Synapse Energy Economics, 2022. (Docket No. E002/M-21-814, available through eDockets)

National Energy Screening Project, *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources*, 2020

Contact

Synapse Energy Economics
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