Regulatory Training Initiative

Benefit-Cost Analysis of Distributed Energy Resources

RTI On-Line Training

Day 2

May 3-5, 2022

1101 Vermont Ave NW, Suite 200 • Washington, DC 20005 • (202) 222-0390 • www.nrri.org

Topics we will cover today

DAY 1

- What is benefit-cost analysis (BCA) testing?
- Key categories and inputs to BCA
- Foundational BCA principles and using a BCA framework

DAY 2 – focus for today

- Developing a primary cost-effectiveness test
- Presenting BCA Results
- BCA across different types of DERs
- Optimizing DERs Across a Utility

DAY 3

- How does BCA differ from rate and bill impact analyses?
- Energy equity: BCA and distributional equity analyses
- Key steps to quantifying impacts values for a BCA

Developing a Primary Cost-Effectiveness Test

Developing a Primary CE Test
(picking up from where we left off yesterday)

STEP 1	Articulate Applicable Policy Goals
STEP 2	Include All Utility System Impacts
STEP 3	Decide Which Non-Utility System Impacts to Include
STEP 4	Ensure that Benefits and Costs are Properly Addressed
STEP 5	Establish Comprehensive, Transparent Documentation

We are now going to walk through a hypothetical example to apply these 5 steps, noting that the BCA Principles are applied throughout multi-step process.

STEP 1 Articulate Applicable Policy Goals

Articulate the jurisdiction's applicable policy goals related to DERs.

Example:

Jurisdiction's Applicable Policies Statutes, Regulations, Plans, Orders, etc.	**Electric Utility System Impacts**	**Goals Reflected in Policies***			
		Reduce Other Fuels	**Reduce GHG Emissions**	**Water Savings**	**Protect Low Income Customers**
Net Metering Policy	DG	DG	DG		
Distributed Storage Goal	DS	DS	DS		
Energy Efficiency Statute	EE	EE	EE	EE	EE

*Assumes broadest application of policy goals across all DERs for BCA purposes.

* ALSO, assumes that there is NO policy that requires accounting for host customer impacts in cost-effectiveness testing

STEP 2 Include All Electric Utility System Impacts

Identify and include the full range of utility system impacts in the primary BCA test, and any secondary tests

Type	Utility System Impact	EE	DG	DS
Generation	Energy Generation	✓	✓	✓
	Capacity	✓	✓	✓
	Environmental Compliance	✓	✓	✓
	RPS/CES Compliance	✓	✓	✓
	Market Price Effects	✓	✓	✓
	Ancillary Services	✓	✓	✓
Transmission	Transmission Capacity	✓	✓	✓
	Transmission System Losses	✓	✓	✓
Distribution	Distribution Capacity	✓	✓	✓
	Distribution System Losses	✓	✓	✓
	Distribution O&M	✓	✓	✓
	Distribution Voltage	✓	✓	✓
General	Financial Incentives	✓	✓	✓
	Program Administration	✓	✓	✓
	Utility Performance Incentives	✓	✓	✓
	Credit and Collection Savings	✓	✓	✓
	Risk	✓	✓	✓
	Reliability	✓	✓	✓
	Resilience	✓	✓	✓

In some cases, the value of the impact might be very small or zero. Ex: the impact of EE on ancillary services.

Nonetheless, the impact should be included in the BCA test, because (a) the value might become significant in the future, and (b) other DER types might have significant values.

Ex: a non-wires alternative program that includes EE, DR, and DS. The same test is used for all three DERs, but for EE the ancillary services impact is zero.

STEP 3 Decide Which Non-Utility System Impacts to Include

Identify those non-utility system impacts to include in the primary test based on applicable policy goals identified in Step 1.

In this hypothetical JST, which non-utility system impacts should be included?

- Other Fuels – Yes, this is relevant to policy goals
- Host Customer Impacts – No, these are not relevant to policy goals
- Societal Impacts – Which of these 'societal' policies are articulated for this jurisdiction in statute, etc.?
  - Protect low-income customers - yes
  - Environmental impacts- yes (GHG emissions and water)
  - Public health impacts - no
  - Energy security - no

STEP 4

Ensure that Benefits and Costs are Properly Addressed

Ensure that the impacts identified in Steps 2 and 3 are properly addressed, where:

- Ensure symmetrical treatment of costs and benefits
  - For example, if host customer costs are included, then host customer benefits should be included as well.
- Ensure no double counting.
  - For example, if environmental benefits and public health benefits are included, any overlap should be netted out.
- Ensure that relevant and material impacts are included.
  - Even those that are hard to quantify.
- Ensure that benefits and costs are treated consistently across DER types

STEP 5

Establish Comprehensive, Transparent Documentation

Establish comprehensive, transparent documentation and reporting

Example

Assumption Category	Assumption Description	Value/Assumption
Utility & Grid Profile	Program Administrator	An investor-owned utility
	Location	A Western state that does not have a Regional Transmission Operator (RTO)
	Regional Generation Mix / Grid Profile	• Significant renewable energy penetration, including solar PV. • Grid reliability constraints, e.g., public safety power shutoff (PSPS)
	Regional Utility Costs	High avoided capacity costs
Policy Context	Key policy/regulatory objectives	• State incentive program (in addition to the proposed program offering) to encourage DER deployment, including storage • Aggressive state-level GHG emissions reductions targets with goal of being carbon neutral by 2050 • Grid reliability concerns • Regulatory policy requires including host customer impacts in cost-effectiveness tests
Reference Case	Baseline Program Assumptions	Small commercial customer installs a 20 kW rooftop solar array, and is on TOU rate
Proposed Program Details	Program Offering	Small commercial customer installs a 20 kW rooftop solar PV array paired with a 14 kW / 86 kWh[25] BESS, and is on a TOU rate. There is a utility and state incentive for BESS installation.
	Financial Incentive for Participants	The state incentive level for participants is $175 per kWh[26] The utility incentive level is $75 per kWh
	DER Operational Profile	BESS can only charge based on the solar PV system (cannot charge from the grid) to fulfill requirements to claim the full ITC value, and will discharge for peak TOU optimization
	Program Customer Type	Commercial (small office building) with regular daytime operations
	Rate Class	Small to medium Commercial & Industrial (C&I) TOU rate class[27]
	Program Offering Time Period/Length	3 years
	Contract Length for TOU rate	10 years

STEP 5

Establish Comprehensive, Transparent Documentation

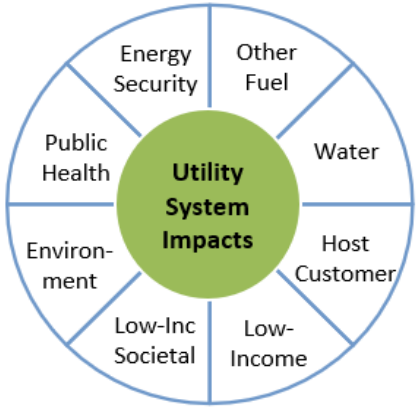
Establish comprehensive, transparent documentation and reporting (Examples)

Example

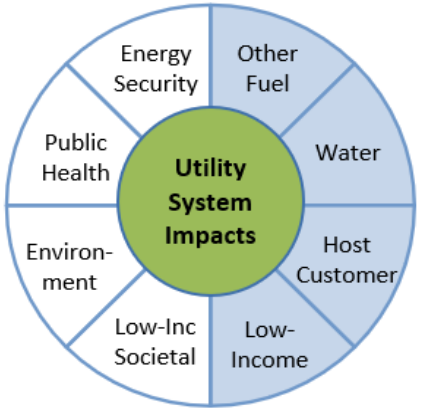
Value Stream	Net Present Value ($ 2021)
ELECTRIC UTILITY SYSTEM IMPACTS	
Avoided Energy	$ 574,605
Avoided Generation Capacity	$ 1,330,213
Avoided Distribution Capacity	$ 112,044
Avoided Transmission Capacity	$ 169,013
Avoided Ancillary Services (A/S)	$ 8,559
Avoided Cap & Trade Cost Compliance	$ 152,494
Avoided Environmental Compliance Costs – GHG Adder	$ 314,347
GHG Rebalancing	$ 75
Reduced Risk	$ 36,355
Utility Program Administration Costs	$ (515,969)
Utility Program Incentive Costs	$ (1,312,030)
HOST CUSTOMER IMPACTS	
Increased Customer Reliability	$ 4,713,688
Federal Tax Credit	$ 2,179,093
State Incentive	$ 3,061,404
Depreciation Benefits	$ 1,451,679
Host BESS Interconnection Costs	$ (29,495)
Host O&M Costs	$ (1,354,660)
Host BESS Capital Cost (net of incentives)	$ (7,069,097)
Total Benefits	**$ 14,103,570**
Total Costs	**$ (10,281,252)**
Net Benefits	**$3,822,318**
Benefit Cost Ratio	**1.37**

Poll #1: Which primary test did we just 'develop' for this Jurisdiction?

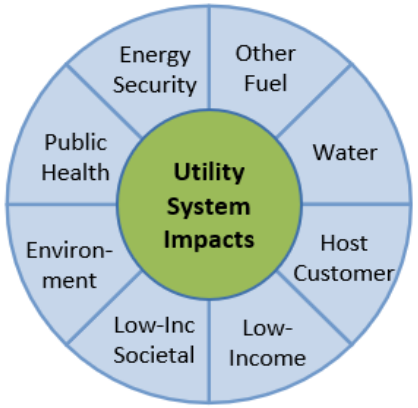
JST 1 = UCT/PACT



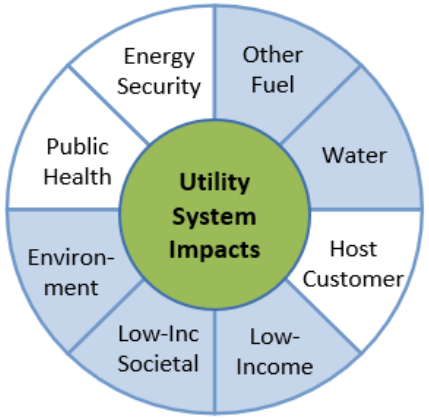
JST 2 = TRC Test



JST 3 = SCT



JST 4 = Unique to Jurisdiction



- All utility system impacts included
- Non-utility system impacts included
- Non-utility system impacts *not* included

UCT = Utility Cost Test (or PACT = Program Admin Cost Test)

TRC = Total Resource Cost Test

SCT = Societal Cost Test

Example: New Hampshire

Type	Impact	Previous Practice	Granite State Test	Secondary Test	Secondary Test
Utility System	Utility System	partially	✓	✓	✓
Participant	Participant costs	✓	x	x	x
	Participant benefits	partially	x	x	x
Other fuels	Other fuels	✓	✓	✓	x
Water	Water	✓	✓	✓	x
Low-income	Low-income	✓	✓	✓	x
Societal	GHG emissions	x	x	✓	x
	Other environmental	x	x	x	x
	Public health	x	x	x	x
	Macroeconomic	x	x	x	x
	Energy Security	x	x	x	x
	Energy Equity	x	x	x	x

Questions on developing a primary cost-effectiveness test?

Presenting BCA Results

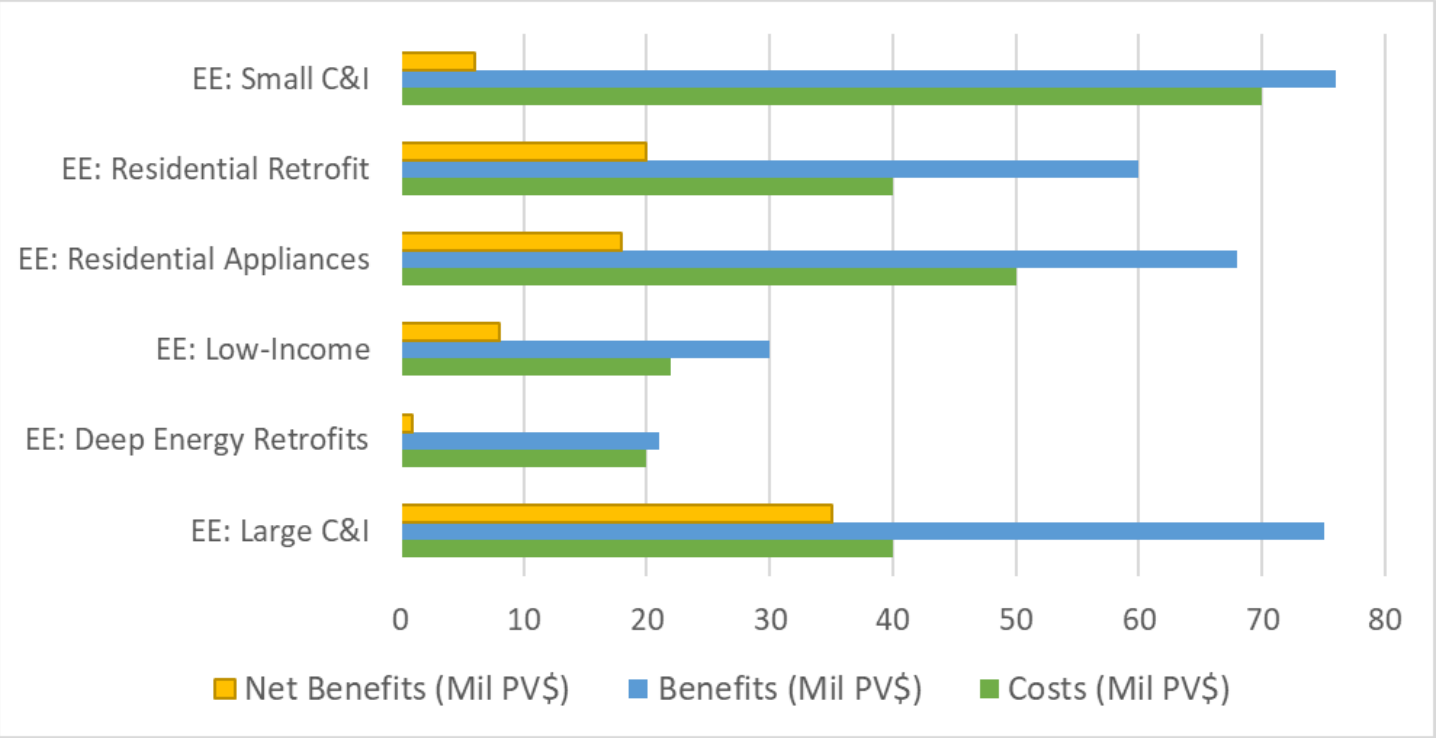
Presenting BCA Results

- There are multiple ways of presenting BCA results, each with different strengths and limitations.
- Options include:
  - Present values of benefits, costs, and net benefits
  - Benefit-cost ratios
  - Levelized costs

Benefits, Costs, and Net Benefits

- Net benefits equal the cumulative present value of benefits minus the cumulative present value of costs.
- Net benefits indicate the magnitude of benefits relative to the magnitude of costs.
- Net benefits cannot be easily compared across DER types, utilities, or jurisdictions because they are of different sizes.

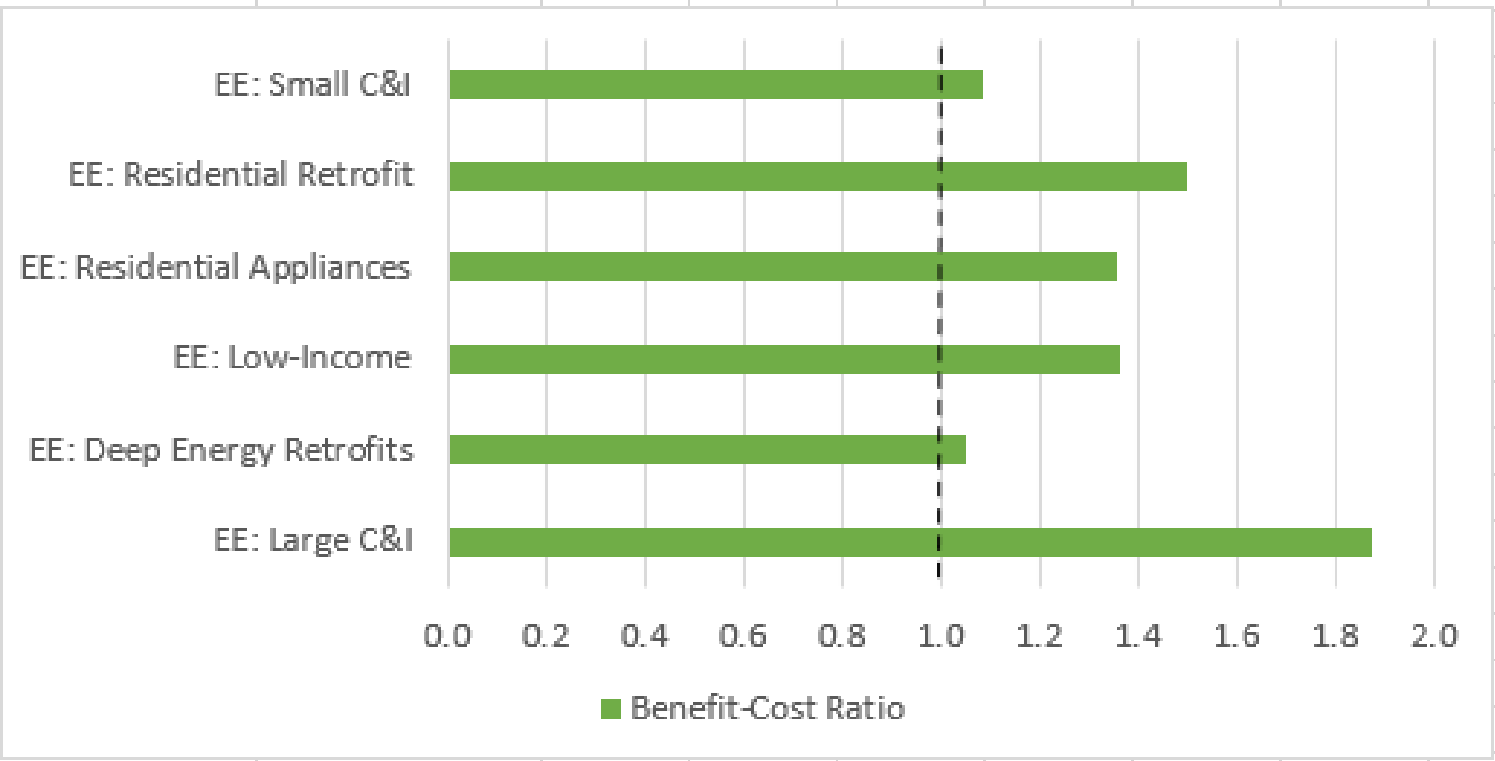
Net Benefits = NPV $\sum$ benefits (dollars) - NPV $\sum$ costs (dollars)



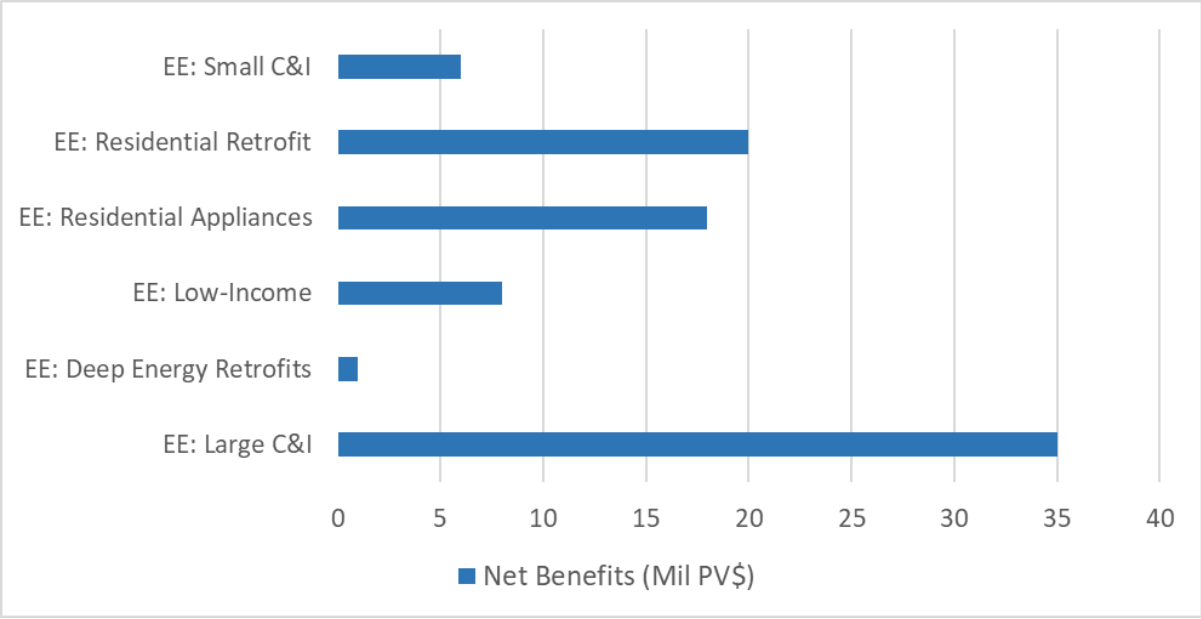
Benefit-Cost Ratios

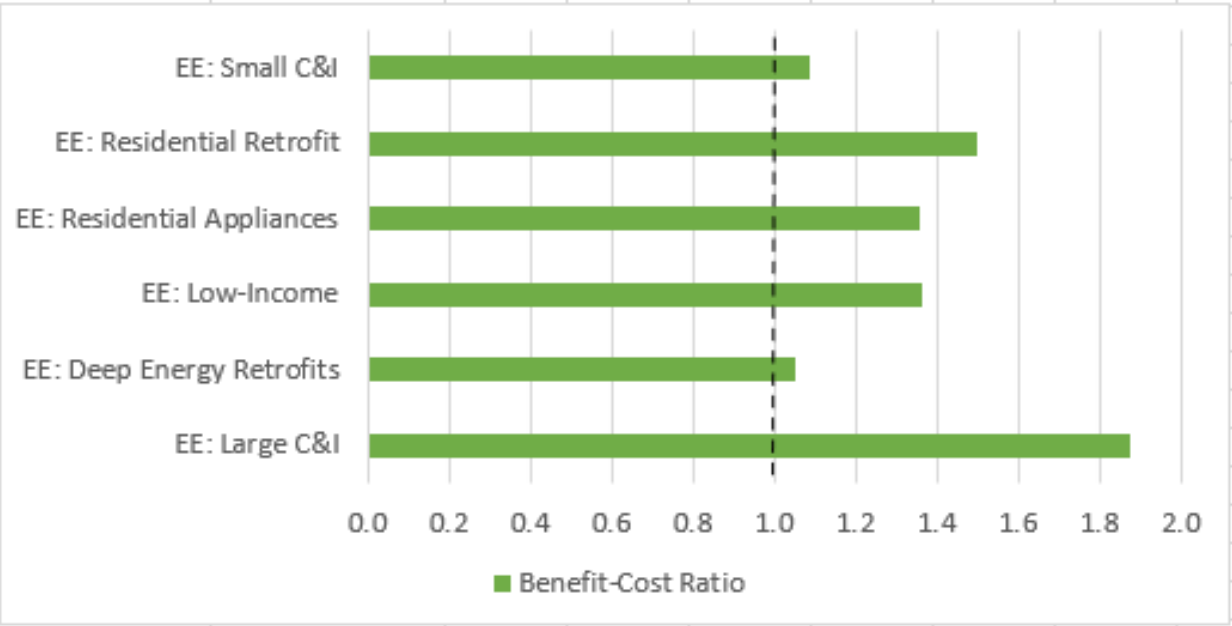
- Benefit-cost ratio (BCR): ratio of the cumulative present value of benefits to the cumulative present value of costs.
- BCRs are useful for comparing different DERs since they 'normalize' results for DERs of different sizes.
- BCRs useful for comparing DERs across utilities and jurisdictions of different sizes.

$$\text{Benefit-Cost Ratio} = \frac{\text{NPV} \sum \text{benefits (dollars)}}{\text{NPV} \sum \text{costs (dollars)}}$$



Benefit-Cost Ratios versus Net Benefits

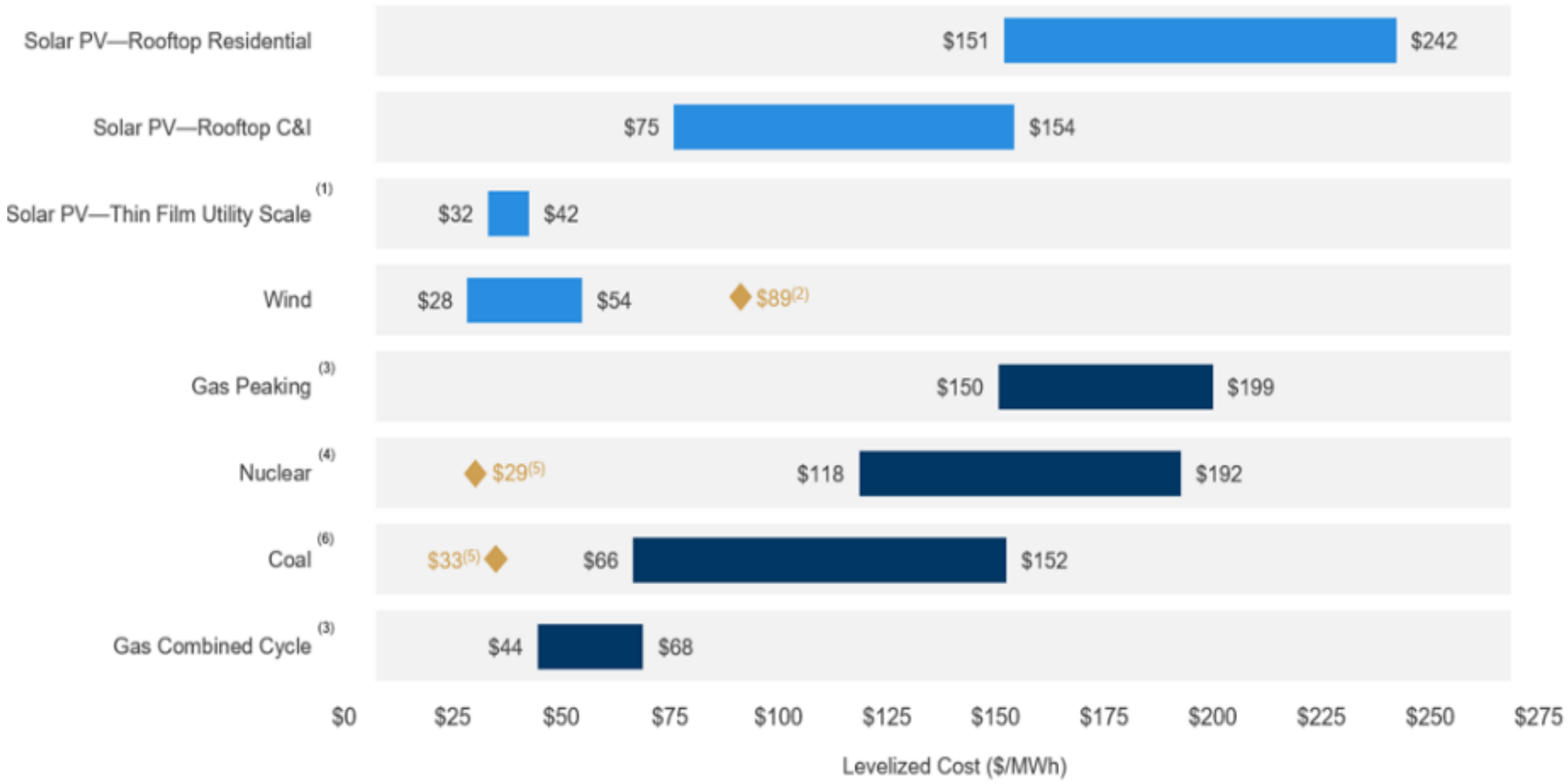




- In this example, the Small C&I and Deep Energy Retrofit programs have the same BCR.
- But net benefits of the Small C&I program are much larger.
- This is because the Small C&I program is much larger in size.

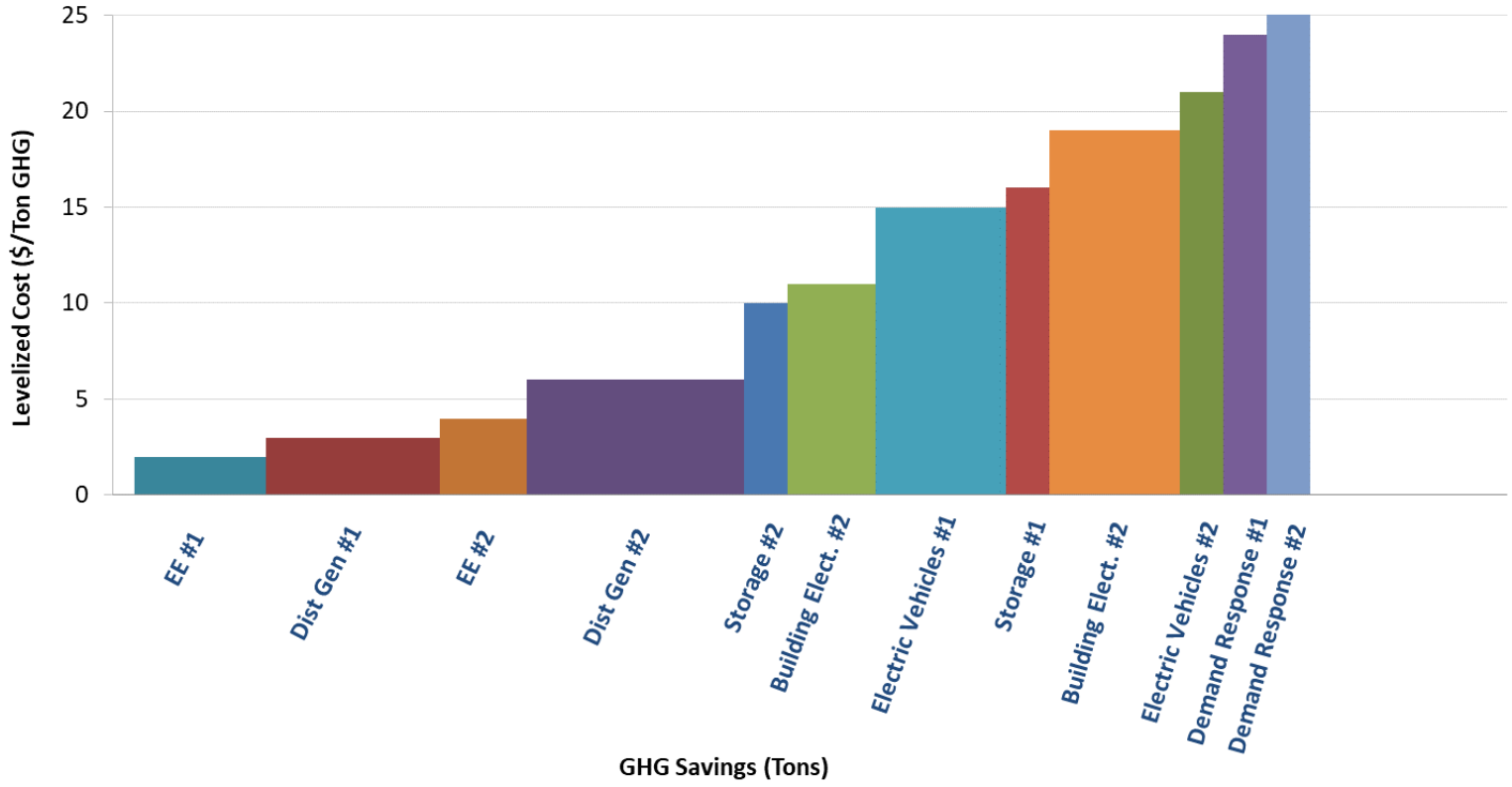
Levelized Costs

- Levelized costs = average cost per unit of energy to install and operate an electricity or gas resource
- Used to compare costs across a variety of resources (supply-side and demand-side resources)
- Says nothing about the benefits.
- Not used as often as BCRs and net benefits, except for specific applications, e.g, $/ton GHG



Source: Lazard, *Levelized Cost of Energy and Storage*, 2019.

Levelized Cost of Carbon Abatement Options



First estimate levelized costs ($/MWh)

Then put into terms of $/ton of GHG abated. This determines the height of each bar.

Estimate the magnitude of GHG savings by DER. This determines the width of each bar.

Sort abatement options from lowest to highest cost per ton of GHG reduced.

Use results to determine which DERs are the lowest cost options for achieving GHG targets.

Questions on presenting the results of BCAs?

Benefit-Cost Analyses Across Multiple Types of DERs

DER Utility System Impacts

Type	Utility System Impact	EE	DR	DG	Storage	Electrification
Generation	Energy Generation	●	●	●	●	●
	Capacity	●	●	●	●	●
	Environmental Compliance	●	●	●	●	●
	RPS/CES Compliance	●	●	●	●	●
	Market Price Effects	●	●	●	●	●
	Ancillary Services	●	●	●	●	●
Transmission	Transmission Capacity	●	●	●	●	●
	Transmission System Losses	●	●	●	●	●
Distribution	Distribution Capacity	●	●	●	●	●
	Distribution System Losses	●	●	●	●	●
	Distribution O&M	●	●	●	●	●
	Distribution Voltage	●	●	●	●	●
General	Financial Incentives	●	●	●	●	●
	Program Administration Costs	●	●	●	●	●
	Utility Performance Incentives	●	●	●	●	●
	Credit and Collection Costs	●	●	●	●	●
	Risk	●	●	●	●	●
	Reliability	●	●	●	●	●
	Resilience	●	●	●	●	○

An impact might be a benefit or a cost.

Or it might depend upon how the DER is designed or used.

● = *typically a benefit*
● = *typically a cost*
● = *either a benefit or cost depending on application*
○ = *not relevant for resource type*

DER Host Customer Impacts

Type	Host Customer Impact	EE	DR	DG	Storage	Electrification
Host Customer	Host portion of DER costs	●	●	●	●	●
	Interconnection fees	○	○	●	●	○
	Risk	●	○	●	●	●
	Reliability	●	●	●	●	●
	Resilience	●	●	●	●	●
	Tax Incentives	●	●	●	●	●
	Host Customer NEIs	●	●	●	●	●
	Low-income NEIs	●	●	●	●	●

● = typically a benefit for this resource type; ● = typically a cost for this resource type; ● = either a benefit or cost for this resource type, depending upon the application of the resource; ○ = not relevant for this resource type

An impact might be a benefit or a cost.

Or it might depend upon how the DER is designed or used.

DER Societal Impacts

Type	Societal Impact	EE	DR	DG	Storage	Electrification
Societal	Resilience	●	●	●	●	●
	GHG Emissions	●	●	●	●	●
	Other Environmental	●	●	●	●	●
	Economic and Jobs	●	●	●	●	●
	Public Health	●	●	●	●	●
	Low Income: Society	●	●	●	●	●
	Energy Security	●	●	●	●	●

● = typically a benefit for this resource type; ● = typically a cost for this resource type; ● = either a benefit or cost for this resource type, depending upon the application of the resource; ○ = not relevant for this resource type

An impact might be a benefit or a cost.

Or it might depend upon how the DER is designed or used.

Poll #2: Which of the following factors affect whether an impact is a benefit or cost?

Select multiple from the list of options:

- DER technology characteristics
- DER technology use case (i.e., operating profile)
- Resource ownership/control
- Temporal and locational impacts
- Interactive effects
- Behind-the-Meter versus Front-of-the-Meter

Several Applications of Multiple DER Types

DER types are combined to achieve greater net benefits than when installed in isolation, such as:

- **Grid-interactive efficient buildings (GEBs**) - where integrated DERs in single building (e.g., large commercial) can minimize impact on grid and optimize services to grid
- **Non-wires alternatives (NWAs)** – where integrated DERs in targeted geographic area can offset need for local distribution investments or upgrades
- **Micro-grids** – where integrated DERs in a neighborhood, industrial facility, campus, or some other combination of customers can enable customers to operate in isolation of the gird if needed.

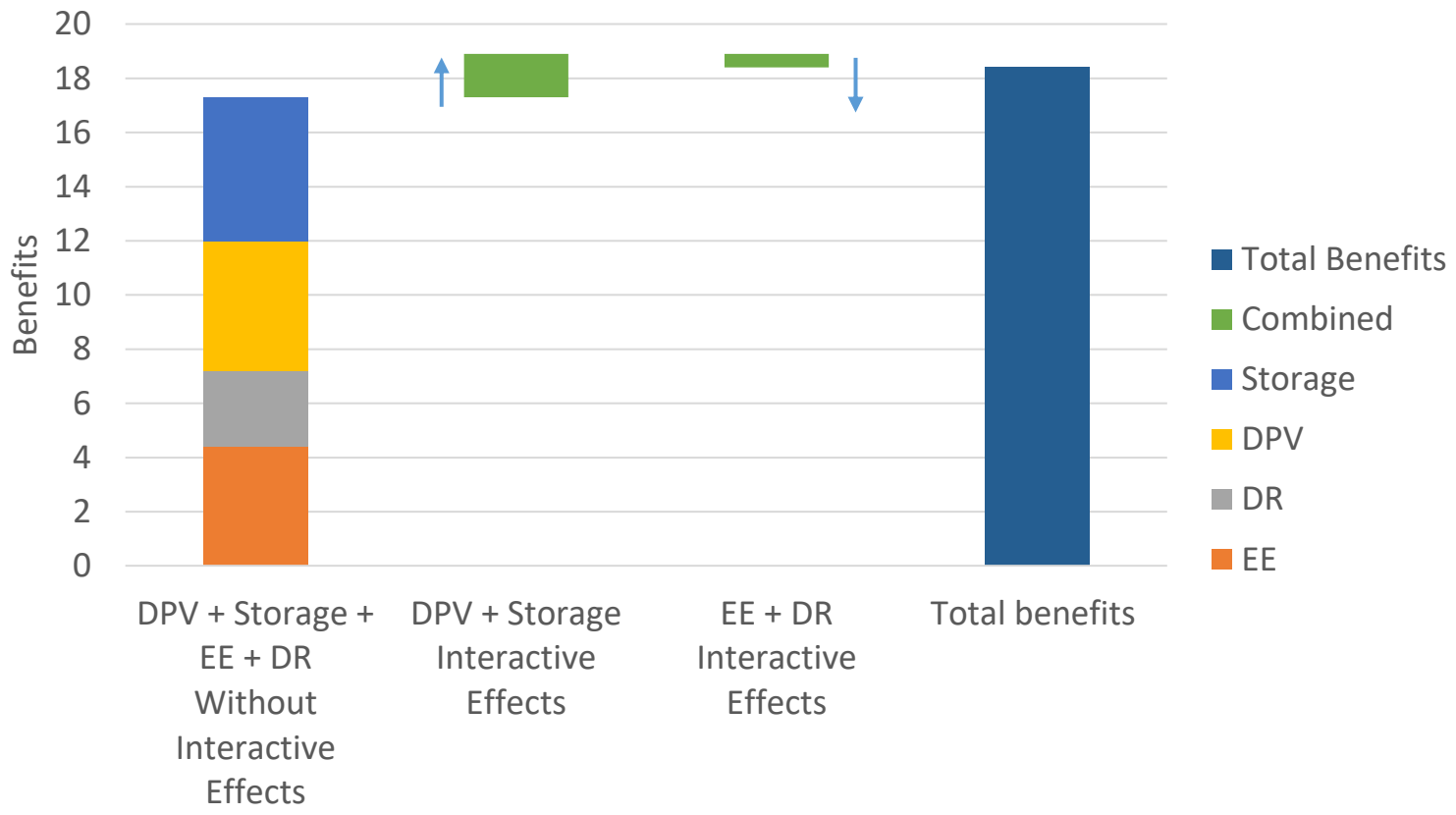
In these applications, necessary to use a consistent BCA test across all the DER types.

Interactive Effects Across DERs

DERs installed in the same service territory, neighborhood, or building can affect the cost-effectiveness of other DER types.

- Can affect marginal system costs, where significant penetration of DERs in one area affects avoided costs of other DERs in that same area.
- Can affect energy and capacity impacts, where one DER affects kWh or kW impacts of other DERs.
  - Example: EE measure lowers host customer load but also reduces demand response kW potential
- Enabling effects, where one DER makes it easier or more cost-effective to adopt other DERs.
  - Example: combined solar plus storage, where adding storage to solar project can improve the economics of the solar project.

Example: Interactive Effects



- Interactive effects can have both positive and negative impacts on BCA.
- In analyzing combined net interactive effects, total benefits are higher overall than without interactive effects.
- It is key to ensure that BCAs fully capture the net potential interactive effects.

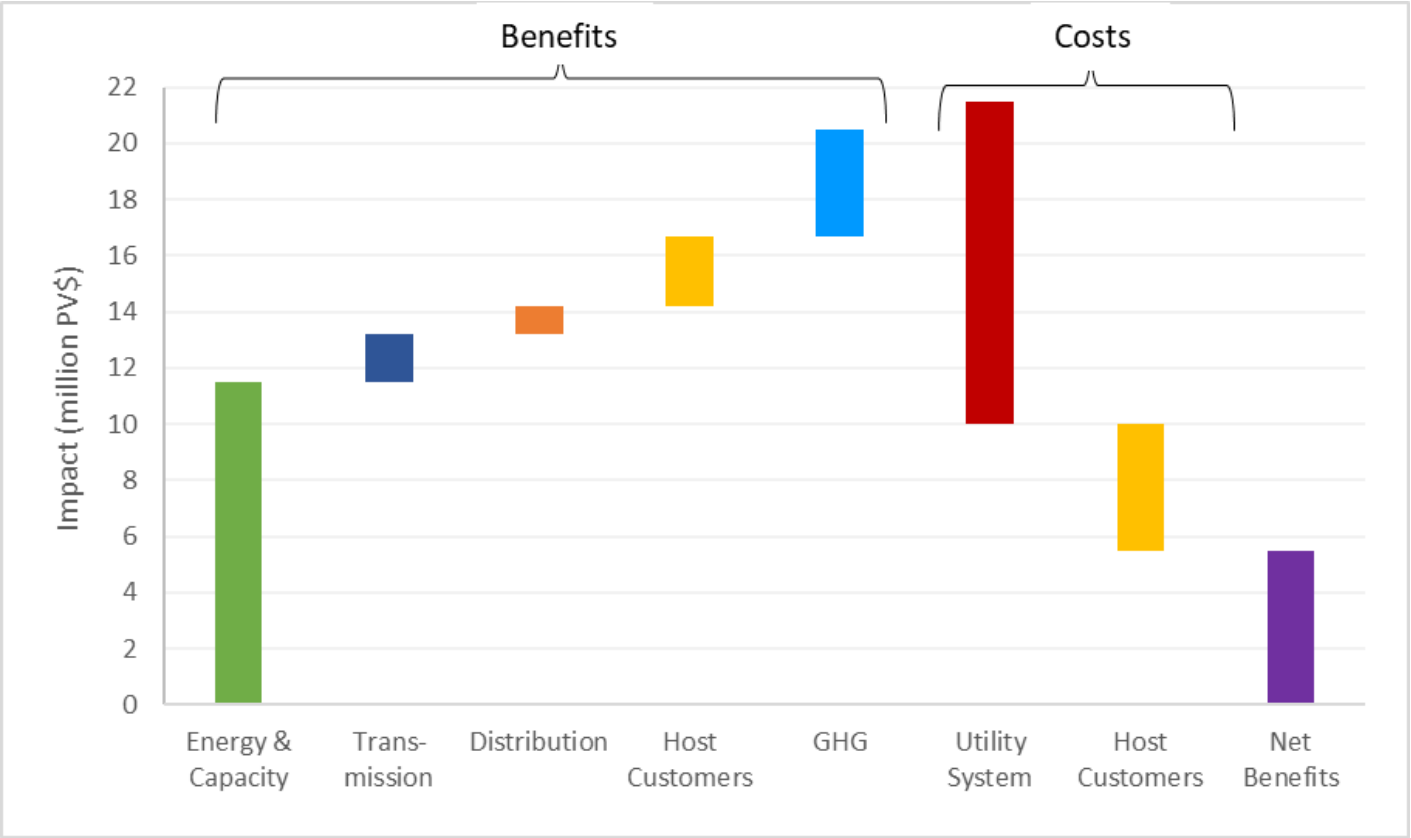
Example: Grid-Interactive Efficient Building

Utility program promotes commercial GEBs to provide:

a) demand flexibility during generation peak hours, and
b) clean resources to meet the jurisdiction's GHG emissions reduction goals.

DERs installed in building: EE, DR, distributed PV, distributed storage.

DERs are operated primarily during <u>generation peak hours</u> to maximize generation capacity benefits.

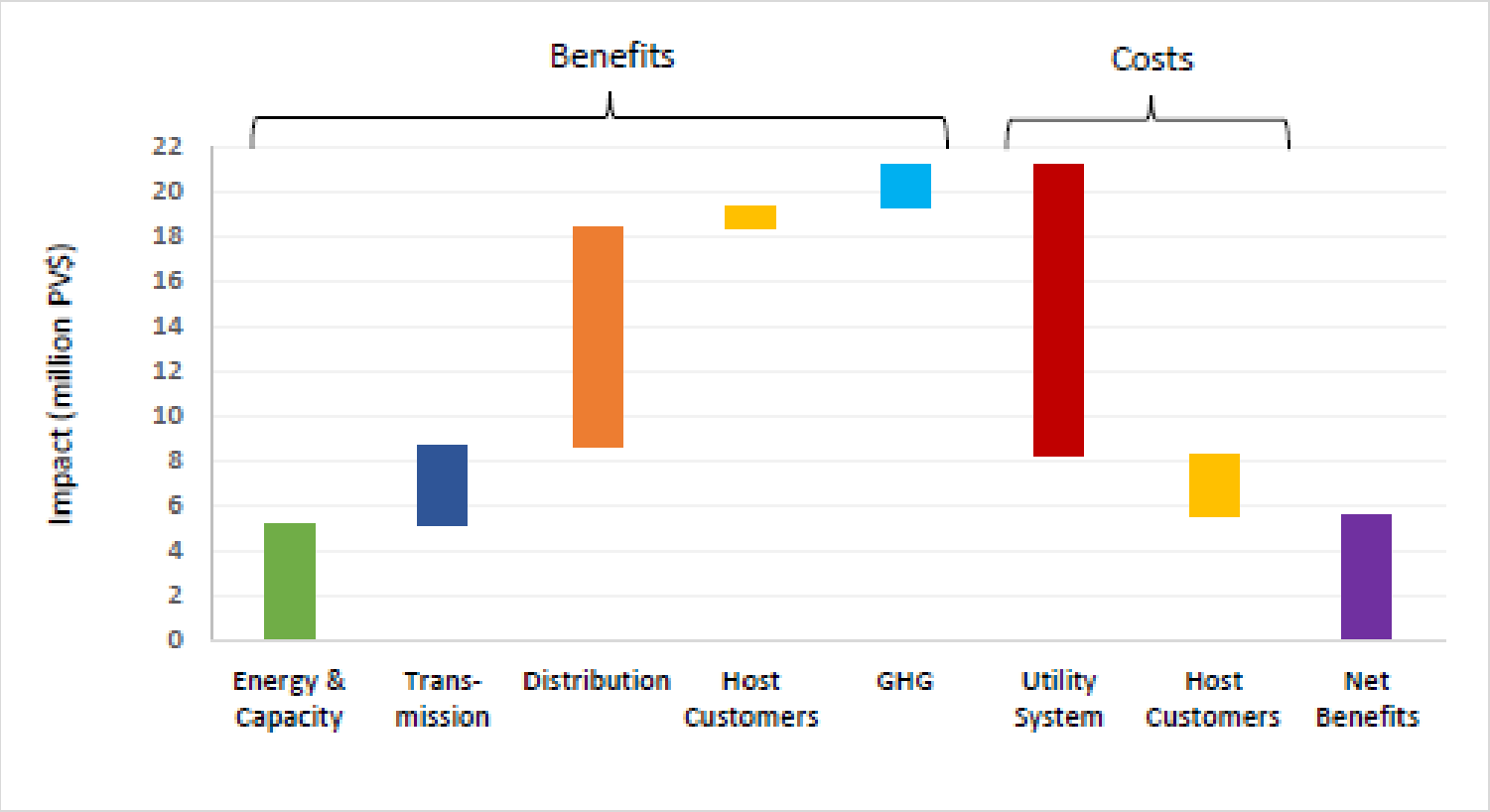


Example: Non-Wires Solution

Utility program promotes geo-targeted DERS avoid the need for a large new substation investment.

DERs installed in geo-targeted region: EE, DR, distributed PV, distributed storage.

DERs are operated primarily during distribution peak hours to maximize distribution benefits.



Questions on applying BCA across multiple DER types

Optimizing Multiple DERs Across a Utility

Multiple DERs Within a Utility

A jurisdiction's primary cost-effectiveness test should be designed to answer the key question:

- Which DERs have benefits that exceed costs and therefore *merit utility funding* or support on behalf of customers?

Once this universe of cost-effective DERs has been identified, some jurisdictions may wish to address a secondary question:

- Which of those cost-effective DERs *should be funded or supported by a utility* on behalf of customers?

Addressing this question should ideally consider all DER types.

Comparison of all DER types should rely upon a single primary BCA test.

Optimizing Multiple DERs Within a Utility

Ideally, utilities should seek to optimize the combination of all DERs within their system.

- Optimizing requires identifying the portfolio of DERs that will result in lowest costs while achieving applicable policy goals.
- Sometimes optimization needs to account for constraints, such as budget constraints.

Optimizing multiple DERs within a utility can be assisted by first establishing the jurisdiction's DER planning objectives. For example:

- Implement all cost-effective DERs
- Implement the most cost-effective DERs
- Encourage customer equity
- Achieve GHG goals at lowest cost
- Avoid unreasonable rate impacts
- Achieve multiple planning objectives

Objective: Implement All Cost-Effective DERs (example)

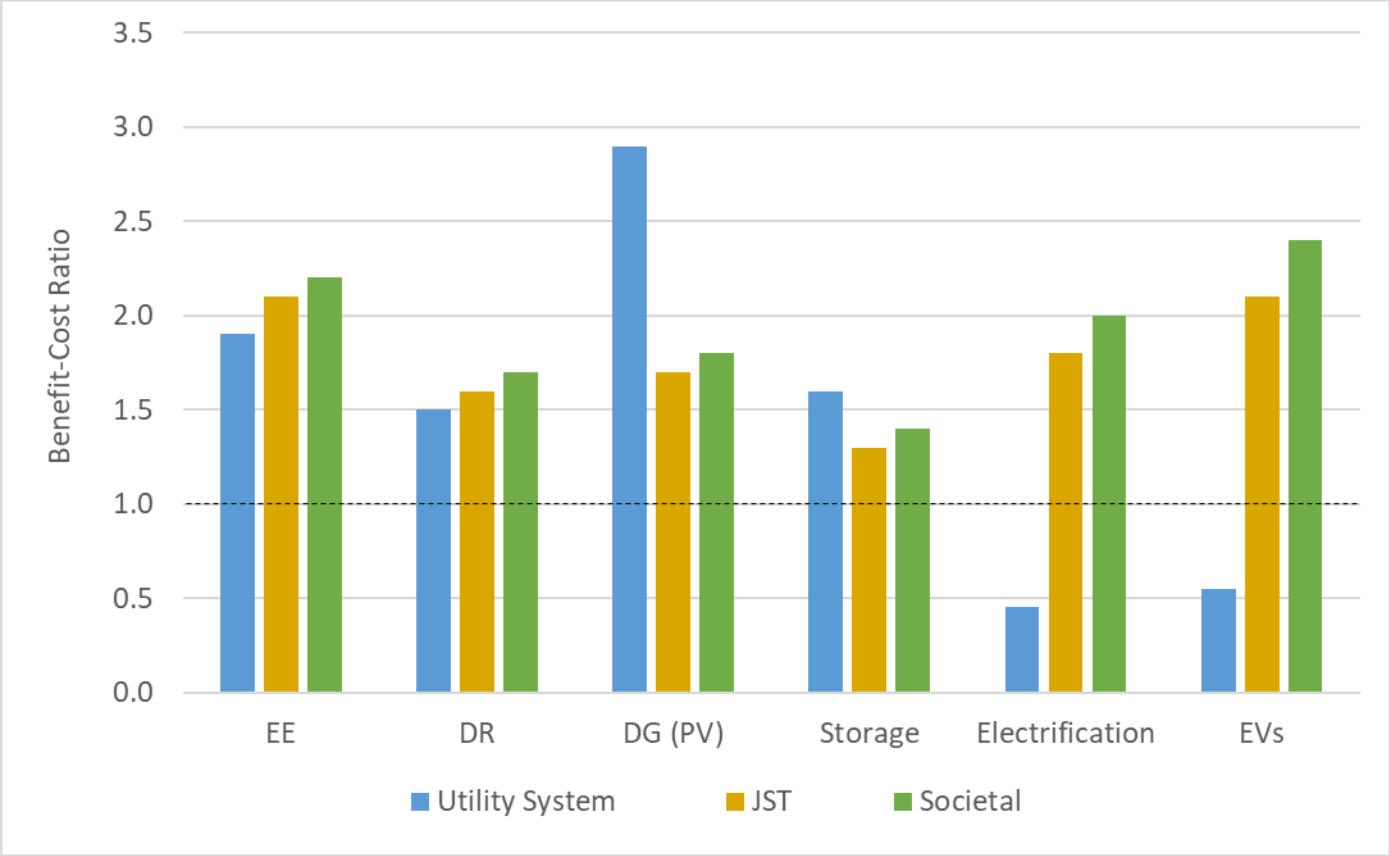
Objective can be met by choosing all DERs that have BCR > 1.0 under the JST.

All DERs are cost-effective under the JST.

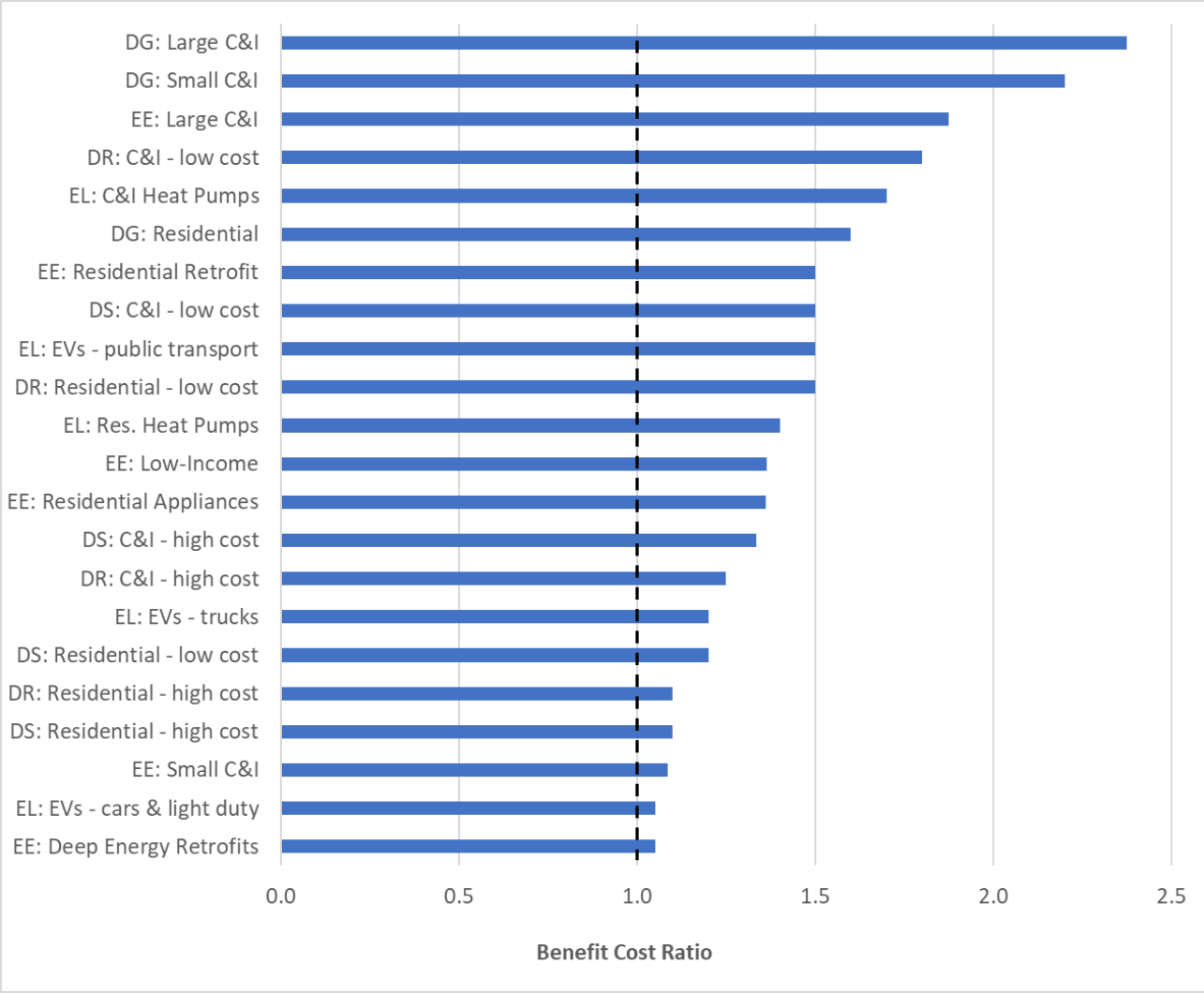
JST includes:

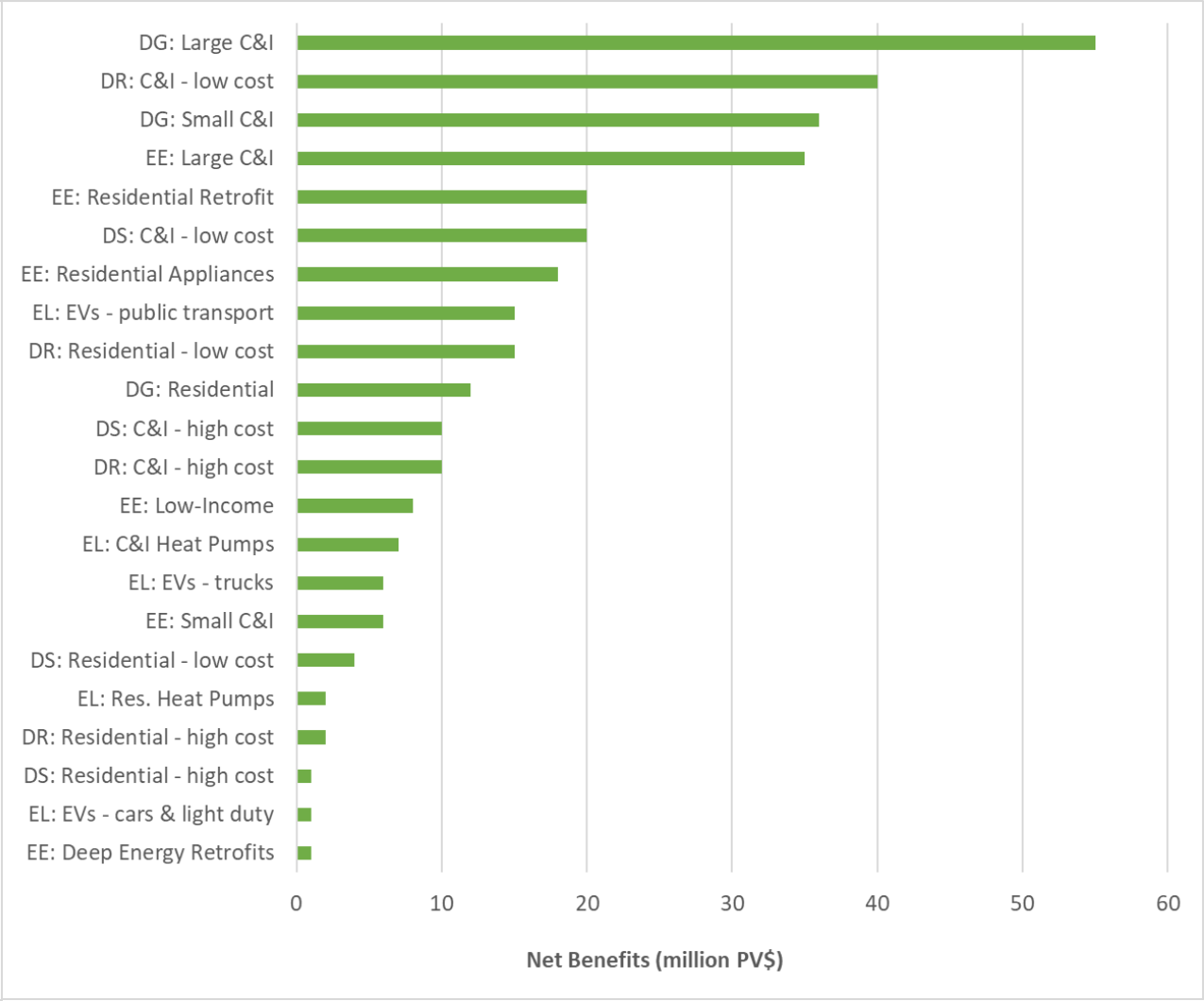
- Utility system impacts
- Host customer impacts
- Other fuel impacts
- GHG impacts

Results of other tests can be presented alongside the results of JST to provide additional information.



Objective: Implement the Most Cost-Effective DERs (example)



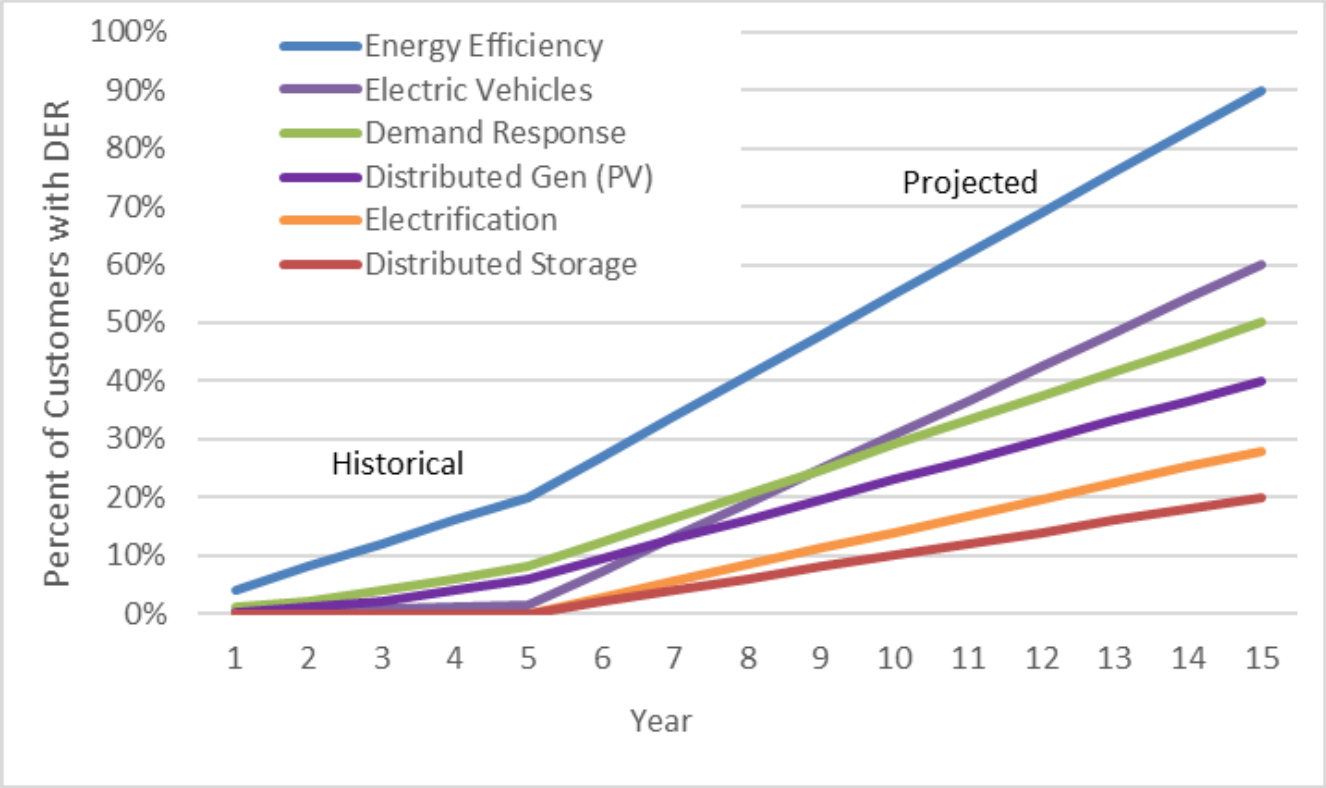


Objective: Encourage Customer Equity (example)

Increased participation in DERs will help address customer equity. (To be discussed further in tomorrow's session.)

But additional considerations might be needed to ensure that all customers have access to DERs. For example:

- Low-moderate income (LMI) DER programs might be less cost-effective than non LMI DER programs but provide important equity benefits.
- Community solar programs can be tailored to LMI customers to ensure that they can access PV.
- EV chargers can be located in economically distressed areas or in public places that are not well-served by privately funded EV chargers.



Objective: Achieve GHG Goals at Lowest Cost (example)

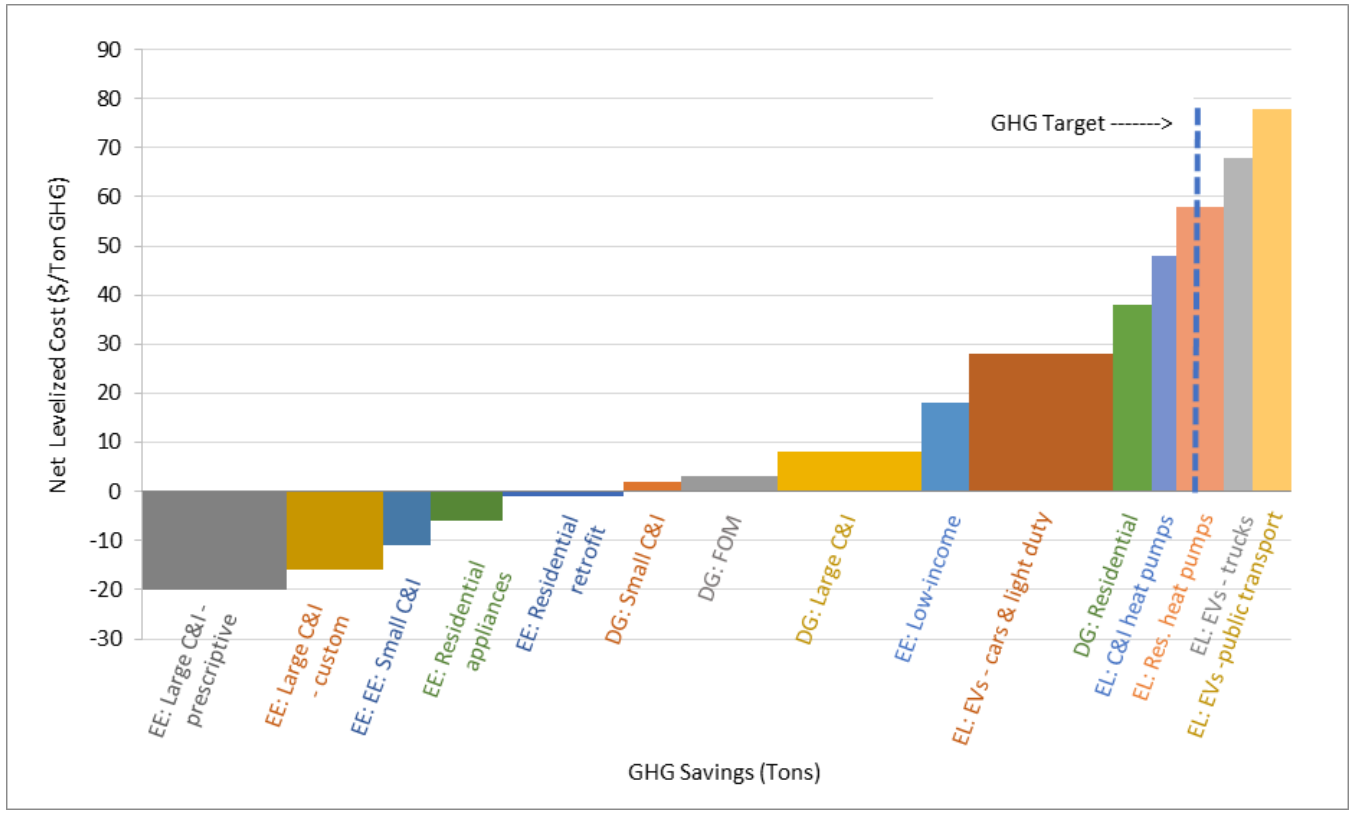
DERs can be ranked according to net levelized cost of reducing GHGs (in $/ton GHG).

Net levelized costs are determined by subtracting the levelized benefits (except GHG benefits) from the levelized costs.

This gives a more complete picture than just the levelized costs (see slide # 22).

All the DERs with net levelized costs less than zero are cost-effective without including GHG benefits.

All the DERs to the left of the GHG target are cost-effective once GHG benefits are included.



Objective: Avoid Unreasonable Rate Impacts (example)

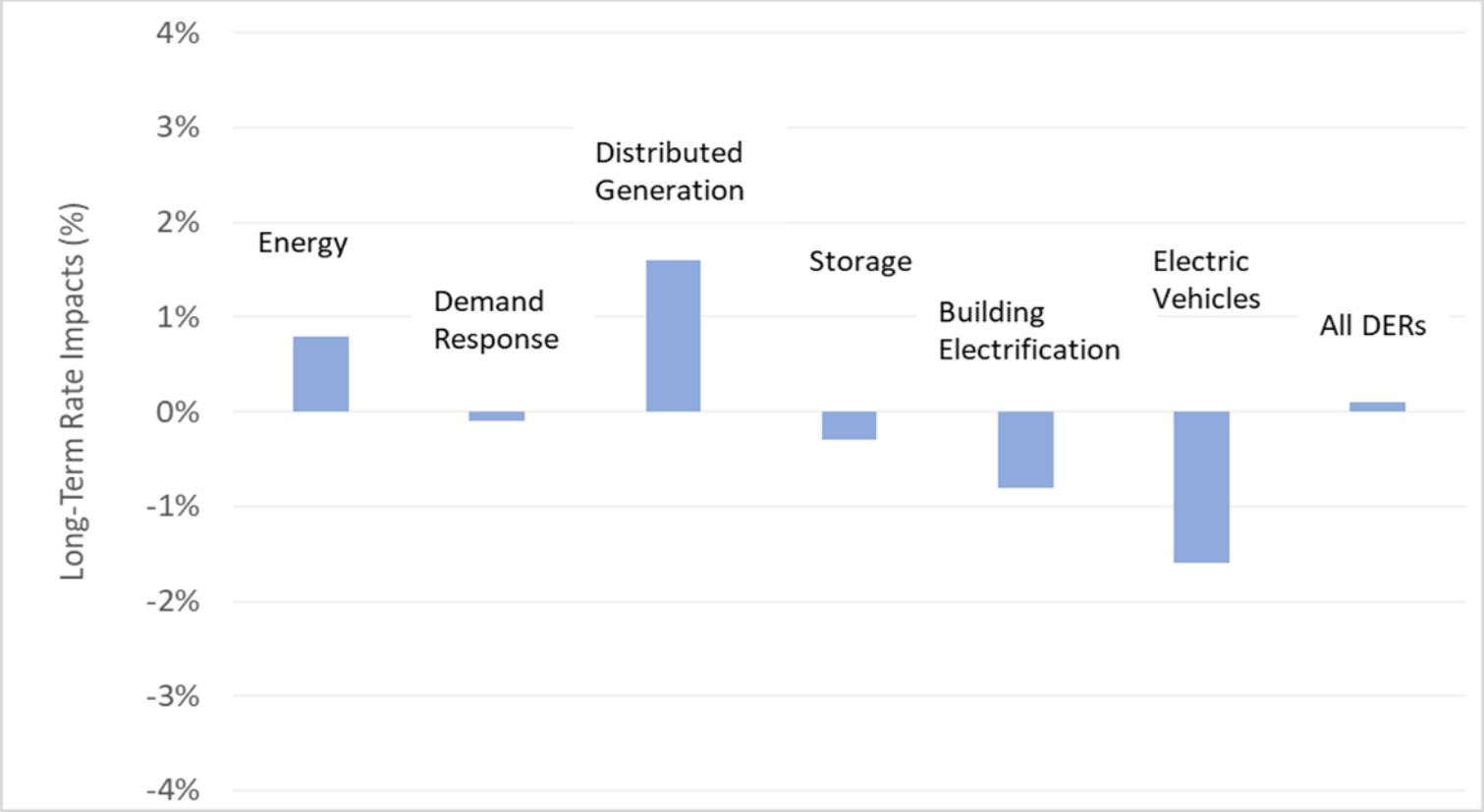
Rate, bill, and participation analyses can be used to determine rate impacts of DERs.

Some DERs will increase rates while others will typically reduce rates.

Consider rate impacts of all DER types together.

- These are the impacts that customers experience.

Rate, bill, and participation analyses will be discussed further in tomorrow's session.



Poll #3: Which of these objectives have you used/considered in your jurisdiction or work?

Pick all that apply:

- Implement all cost-effective DERs
- Implement the most cost-effective DERs
- Encourage customer equity
- Achieve GHG goals at lowest cost
- Avoid unreasonable rate impacts
- Achieve multiple planning objectives

Questions on Optimizing Multiple DERs Within a Utility?

Recap of the Day and What's Coming on Day 3

Key take aways from today:

- Developing a primary cost-effectiveness test (or jurisdiction specific test)
- Presenting BCA Results
- BCA across different types of DERs
- Optimizing multiple DERs across a utility

Questions & Discussion