Regulatory Training Initiative

Benefit-Cost Analysis of Distributed Energy Resources

RTI On-Line Training

Day 3

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

- Developing a primary cost-effectiveness test
- BCA across different types of DERs
- Presenting BCA results
- Optimizing DERs across a utility

DAY 3 – Focus for today

- 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

BCAs Versus Rate, Bill, & Participation Analyses

And Why they Should be Conducted Separately

Conduct BCA Separately from Rate Impacts (NSPM Principle #8)

The two analyses answer different questions

	Benefit-Cost Analysis	Rate Impact Analysis
Purpose	To identify which DERs utilities should invest in or otherwise support on behalf of their customers	To identify how DERs will affect rates, in order to assess customer equity concerns
Questions Answered	What are the future costs and benefits of DERs?	Will customer rates increase or decrease, and by how much?
Results Presented	• Cumulative costs (PV$) • Cumulative benefits (PV$) • Cumulative net benefits (PV$) • Benefit-cost ratios	• Rate impacts (c/kWh, %) • Bill impacts ($/month, %) • Participation rates (#, %)

The Rate Impact Measure (RIM) Test is sometimes used for BCA purposes. However, it combines the two analyses and therefore makes it difficult to answer either question

Components of BCAs versus Rate, Bill, and Participation Analyses

	Include in Benefit-Cost Analysis	Include in Rate, Bill, Participant Analysis
Utility system impacts	✓	✓
Host customer impacts	depends on policy goals	do not affect rates
Social impacts	depends on policy goals	do not affect rates
Lost revenues	do not affect costs	✓
Increased revenues	do not affect costs	✓
Net metering bill credits	do not affect costs	✓

Source: NSPM for DERs Appendix A - Rate Impact Analyses

Rate, Bill, and Participant Impacts

A thorough understanding of rate impacts requires an analysis of three important factors:

- **Rate impacts**, provide an indication of the extent to which rates for all customers might increase.
- **Bill impacts**, provide an indication of the extent to which customer bills might be reduced for those customers that install DERs.
- **Participation impacts**, provide an indication of the portion of customers that will experience bill reductions or bill increases.
    - Participation impacts are also key to understanding the extent to which customers are adopting DERs based on DER policies.

Rate, bill, and participant impacts address one aspect of customer equity: participants typically experience higher bill savings than non-participants.

Rate Impacts

Definition: Change in customer rates from the DER(s)

Total rate impacts driven by 3 factors:

1. The cost of the DER.
2. The costs avoided by the DER.
3. Changes in electricity or gas sales.

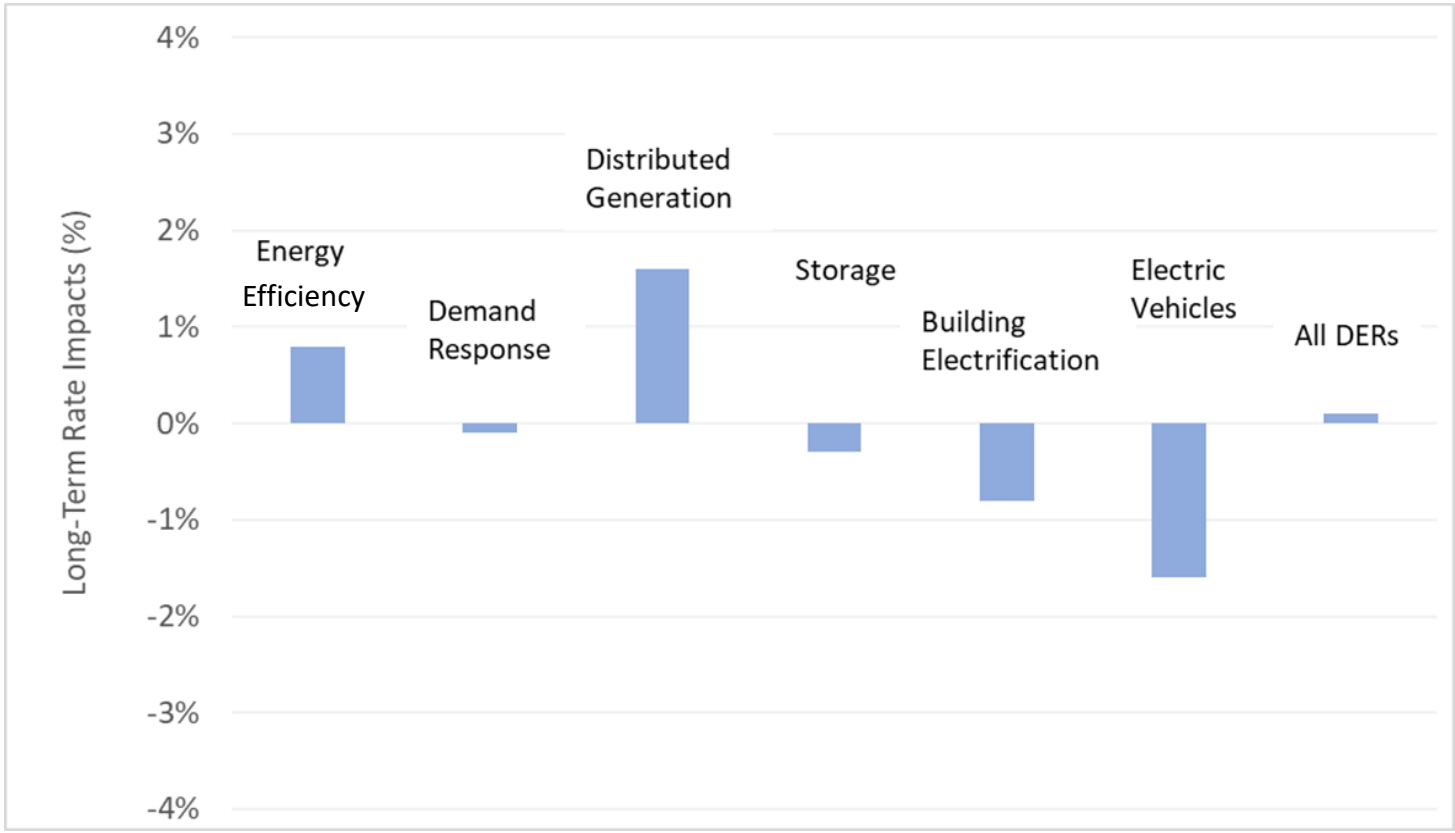
Rate impacts should be presented in terms of long-run averages.

- Short-run impacts do not tell the whole story.

Consider rate impacts of all DER types together.

- These are the impacts that customers experience.

Illustrative Example:



Bill Impacts

Definition: Change in customer bills from the DER(s)

Bill impacts are driven by two factors:

1. The rate impacts
2. The participant savings from the DER(s)

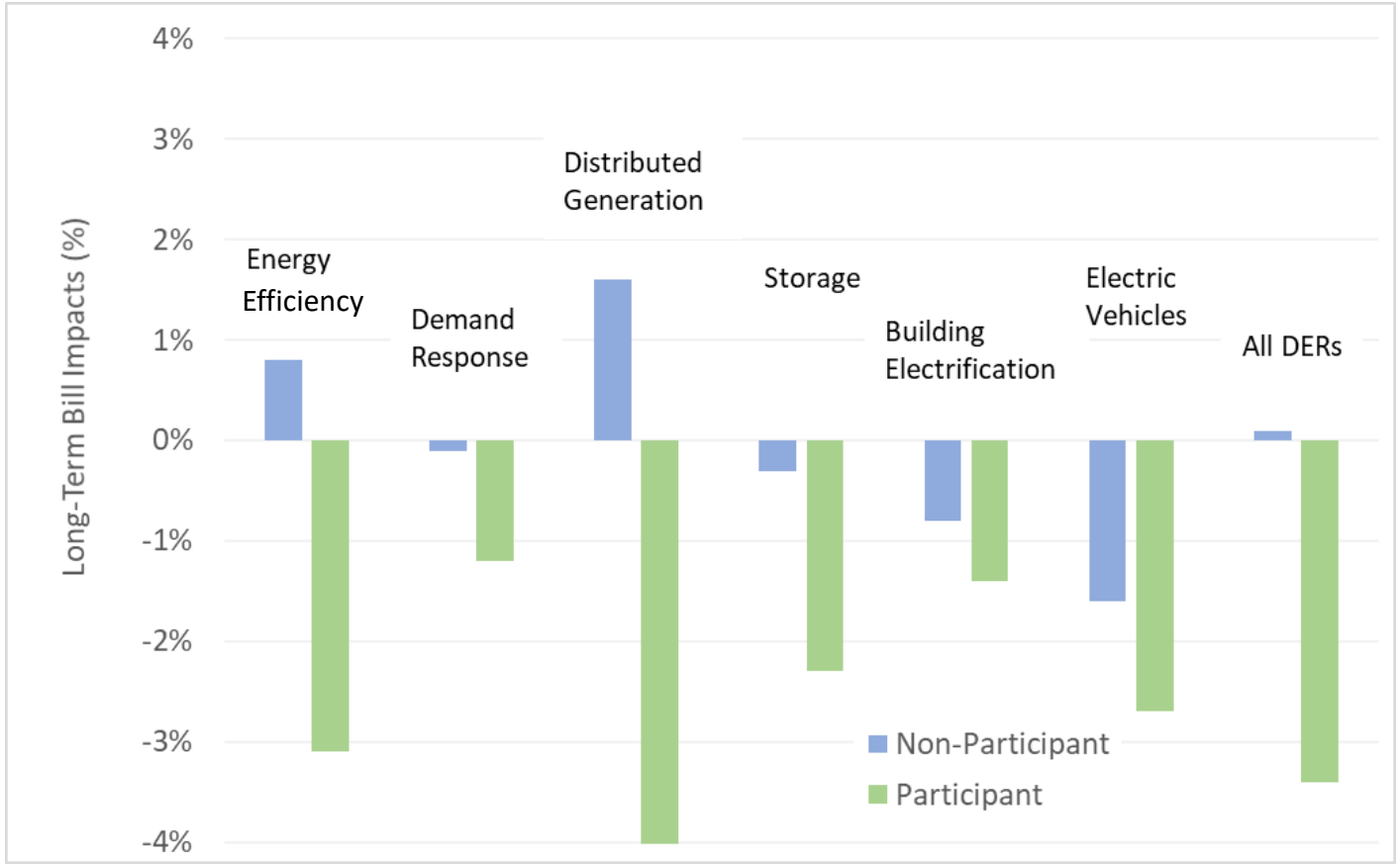
For DER non-participants, the bill impacts will be the same as the rate impacts.

Estimate bill impacts of both the DER participants and non-participants.

- This difference lies at the heart of the customer equity issue.

Consider bill impacts of all DER types together.

Illustrative Example:



Participation Rates

Definition: The percent of the eligible customers that adopt a DER.

Present in terms of long-term impacts.

- Because bill savings can last for many years.

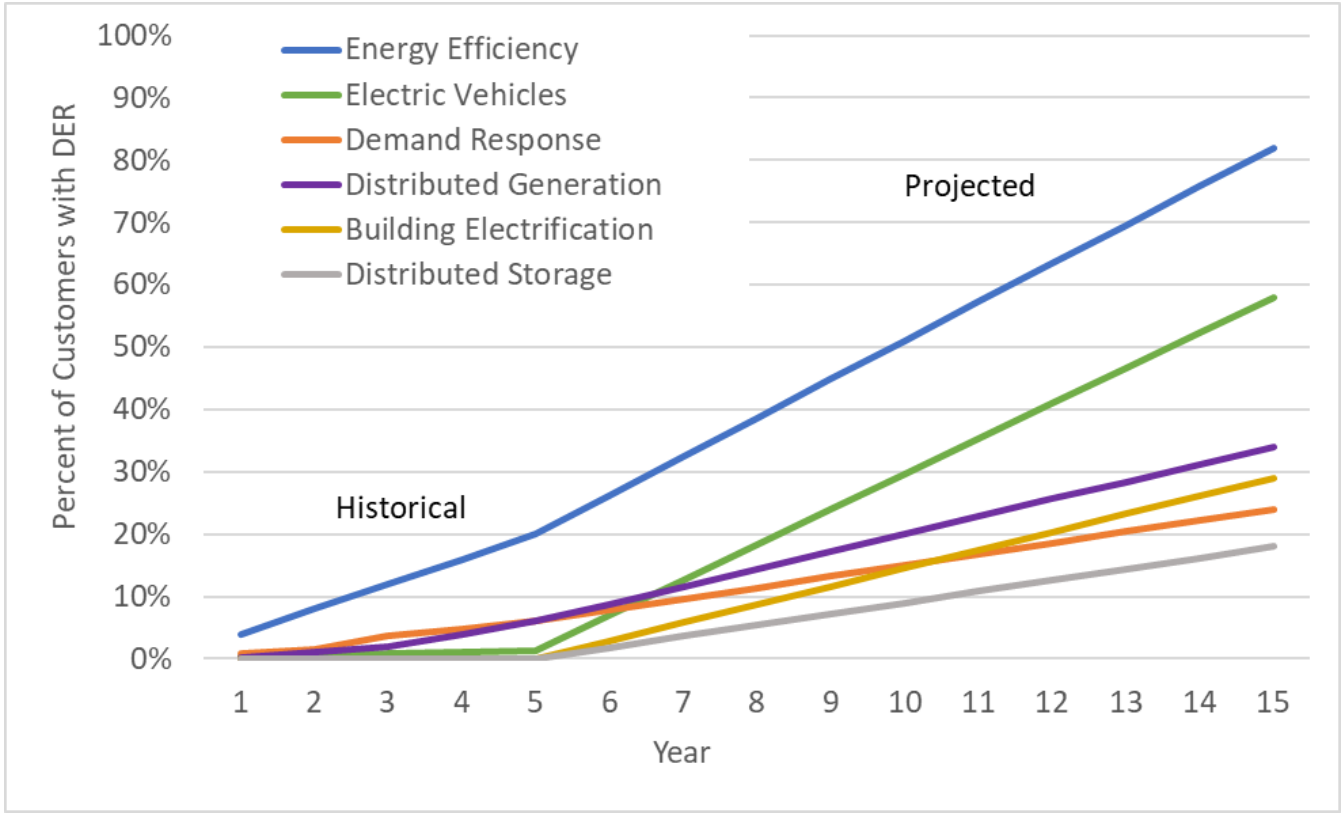
Account for unique participants:

- Some customers might participate in more than one DER program.
- Some customers might participate in one EE or DR program for multiple years.

In general, greater participation helps to mitigate customer equity issues:

- More customers experience bill savings.

Illustrative Examples:



Consider Both BCA and Rate Analyses

Sometimes it is necessary to make tradeoffs between reduced costs and higher rates.

Illustrative example: Energy Efficiency Portfolio

Benefit-Cost Analysis	Net Benefits (mil PV$)	85
	Benefit-Cost Ratio	2.1
Rate Impact Analysis	Long-Term Rate Impacts (%)	1.3
	Bill Impacts Participants (%)	-3.4
	Participation Rate (%) Participation Low-Income (%)	48 56
Additional Considerations (non-monetary)	GHG Goal Achieved (%)	28

significant net benefits...

but rates increase...

but many customers participate and see lower bills.

and there is a big impact on key policy goal

Consider Both BCA and Rate Analysis

Sometimes there are no tradeoffs.

Illustrative Example: Demand Response Portfolio

Benefit-Cost Analysis	Net Benefits (mil PV$)	15
	Benefit-Cost Ratio	1.4
Rate Impact Analysis	Long-Term Rate Impacts (%)	-0.1
	Bill Impacts Participants (%)	-1.2
	Participation Rate (%) Participation Low-Income (%)	18 11
Additional Considerations (non-monetary)	GHG Goal Achieved (%)	3

← some net benefits...

← modest rate decrease...

← Few customers participate...

← not much impact on key policy goal

Consider Both BCA and Rate Analysis

Consider combined effect of all DER types:

Illustrative Example: EE, DR, DG, Storage, Electrification, EVs

Benefit-Cost Analysis	Net Benefits (mil PV$)	305	very large net benefits...
	Benefit-Cost Ratio	1.6	
Rate Impact Analysis	Long-Term Rate Impacts (%)	0.5	modest rate increase...
	Bill Impacts Participants (%)	-3.4	
	Participation Total (%) Participation Low-Income (%)	73 64	many customers participate
Additional Considerations (non-monetary)	GHG Goal Achieved (%)	54	Significant carbon reductions

Poll #1: Which of the following does your jurisdiction conduct?

- ❑ Rate analyses of DERs
- ❑ Bill analyses of DERs
- ❑ Participation analyses of DERs
- ❑ Rate Impact Measure test of DERs

Discussion/Questions on Rate Impacts vs BCA

Energy Equity

How to Use BCAs and Distributional Equity Analyses

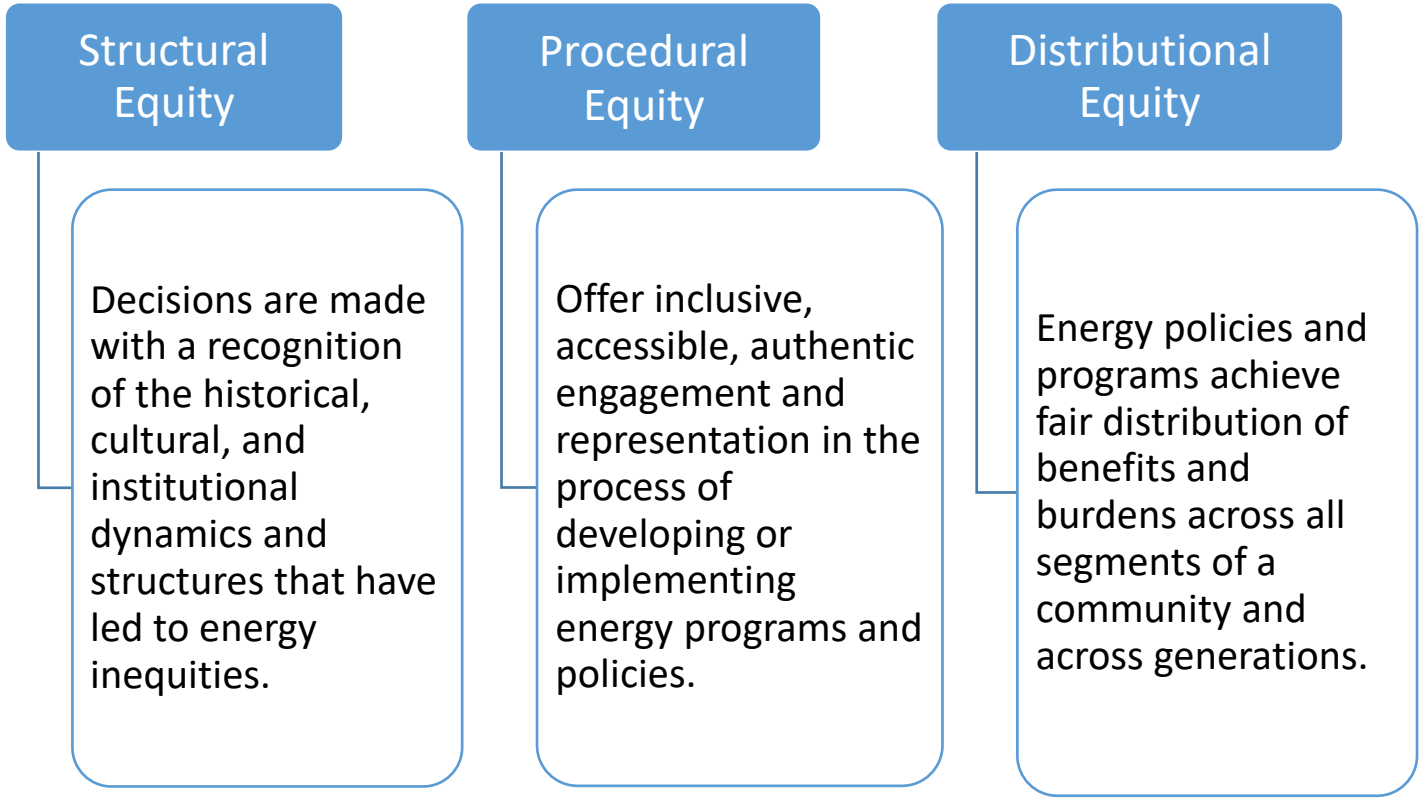
Energy Equity: Definition

Energy equity recognizes that disadvantaged communities have been historically marginalized and overburdened by pollution, underinvestment in clean energy infrastructure, and lack of access to energy-efficient housing and transportation.

An equitable energy system is one where the economic, health, and social benefits of participation extend to all levels of society, regardless of ability, race, or socioeconomic status. Achieving energy equity requires intentionally designing systems, technology, procedures, and policies that lead to the fair and just distribution of benefits in the energy system.

Source: Pacific Northwest National Laboratory, *PNNL's Visions Statement for Equity in the Power Grid*, PNNL website: https://www.pnnl.gov/projects/energy-equity#:~:text=What%20is%20energy%20equity%3F,energy%2Defficient%20housing%20and%20transportation

Several Dimensions of Energy



BCAs <u>do not</u>:

- Directly address structural equity.
- Directly address *procedural* equity.
  - Except that all customers and communities should be able to provide input to BCAs.

BCAs can help to:

- Address *distributional* equity.
  - But not in isolation.
- Address *transgenerational* equity.

Energy Equity: Target Populations

Regulators and others have always been concerned with equity

- Most attention has been to ensure customer equity *between customer classes* (residential, small C&I, large C&I, street lighting, municipalities, etc.)
  - Primarily through rate design and cost allocation in rate cases

Now stakeholders increasingly seeking to promote equity to subgroups of customers: vulnerable, disadvantaged, marginalized etc.

- Also referred to as “target populations”

Target populations are sometimes subsets of classes and sometimes span across classes.

- Therefore, new techniques are required to identify, analyze, and develop programs and solutions to address these customers

Examples of Target Populations

Targeted Population	Definition
Underserved Populations	People who have limited or a decreased level of service or access to energy system services
Marginalized Populations	People excluded from participating in decision-making and those who lack access to basic economic, political, cultural, and social activities.
Vulnerable Populations	Those who are economically disadvantaged, racial and ethnic minorities, the elderly, rural residents, linguistically isolated, those with inadequate education, and those with other socioeconomic challenges.
Highly Impacted Populations	Communities living in geographic locations characterized by energy inequity and facing economic or historical barriers to participation in energy decisions and solutions.
Disadvantaged Populations	Those who most suffer from economic, health, and environmental burdens.
Over-Burdened Populations	Minority, low-income, tribal or indigenous populations, or geographic locations that potentially experience disproportionate environmental harms and risks.
Fenceline Populations	Communities living in closest proximity to dangerous facilities (within one-tenth of a facility's vulnerability zone). Also referred to as 'frontline' populations.
Low- to moderate-income people	People who make less than a certain income threshold relative to the area median income

Source: Pacific Northwest National Laboratory, *Review of Energy Equity Metrics,* October 2021, Table 1.

BCAs and Distributional Equity

- Distributional equity requires assessing *which customers* experience the costs and benefits of utility programs and investments.
- BCAs are not designed to address distributional equity.
  - Instead, they are designed to measure the costs and benefits *on average* across the utility system, broad customer categories, host customers, or society. For example:
    - Avoided costs (i.e., benefits) in BCA are typically a blend of avoided costs experienced by all customers – no distinction made for customer categories/target populations. Consequently, no way to distinguish net benefits to target populations.
  - One exception: DER programs designed to serve target populations (e.g., low-income programs) can be evaluated separately from other programs to show whether those programs will provide net benefits to that population. But *this says nothing about how all the other DER programs will affect the target populations.*
- BCAs can help address distributional equity issues if they are supplemented with a *distributional equity analysis* (DEA).

Distributional Equity Analysis (DEA)

DEAs can be designed to explicitly account for the difference in impacts between target populations and other customers.

- In ways that BCAs cannot.

Rate, bill, and participation analyses are a type of DEA.

- They help to reveal equity issues between host customers and other customers.
- While this is very useful information, it says nothing about target populations.

Rate, bill, and participation analyses can be expanded to include:

- Impacts on target populations
- Additional metrics related to energy equity

Distributional analysis has been used by the Federal government for years.

- But it is new to the electricity industry

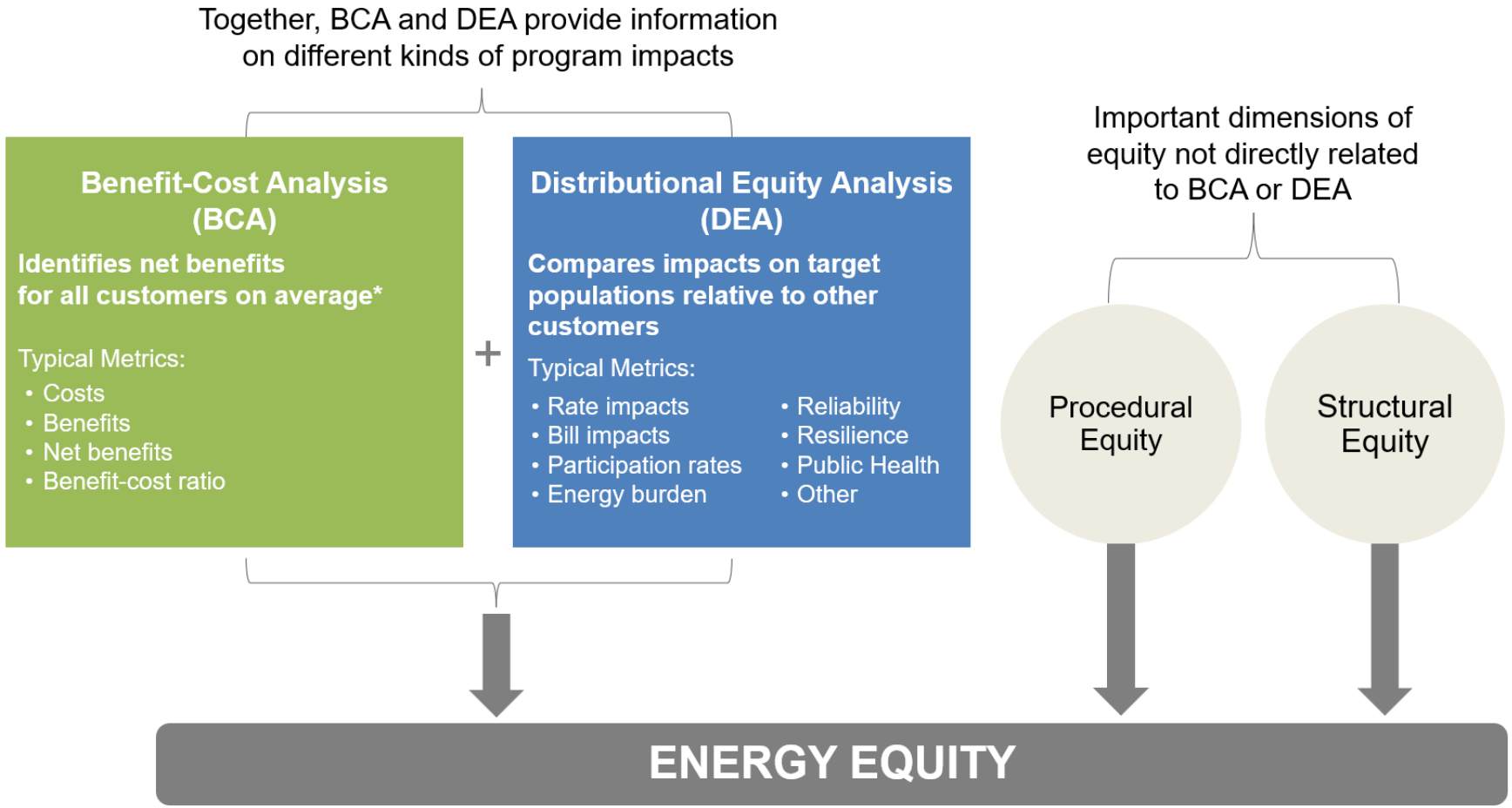
BCA vs Distribution Equity Analysis (DEA)

	Benefit Cost Analysis	Rate, Bill, Participation Analysis	Distributional Equity Analysis
Purpose	To identify which DERs utilities should invest in or support on behalf of customers on average	To identify how DERs affect host versus non-host customers	To identify how DERs affect target populations versus other customers
Questions Answered	What are the costs and benefits of DERs across customers and (if applicable) society on average? What are the costs and benefits of a DER program designed for target populations?	What is the impact of DERs on host versus non-host customers?	What is the impact of DERs on target populations versus other customers?
Example Metrics for Reporting Results	Costs (PV$) Benefits (PV$) Net benefits (PV$) Benefit-cost ratios	Rate Impacts ($/kWh) Bill Impacts ($/month) Participation rates (% of eligible customers)	<u>Impacts on target populations:</u> Rate Impacts ($/kWh) Bill Impacts ($/month) Participation rates (% of eligible) Additional Impacts: • Energy burden ▪ Public health • Reliability ▪ Other • Resilience

BCAs and Transgenerational Equity

- Transgenerational equity:
  - How utility resource and investment decisions made in the short-term will affect customers over both the short-term and the long-term.
- BCAs address transgenerational equity through choice of **discount rate** used to calculate present values of costs and benefits.
- Discount rates reflect the *time preference* for short-term versus long-term impacts:
  - Lower discount rates → greater weight on future impacts, promotes transgenerational equity
  - Higher discount rates → less weight on future impacts, undermines transgenerational equity

BCA vs Distribution Equity Analysis (DEA)



*Non-utility system impacts can be accounted for in BCAs if consistent with the jurisdiction's policy goals, but inclusion of these impacts in BCA does not provide a measure of equity across target populations.

Poll #2: Has your state/jurisdiction undertaken any of the following?

- ❑ Established energy equity as an energy policy goal
- ❑ Defined any target populations for addressing equity
- ❑ Defined any metrics that can be used to monitor equity
- ❑ Established dockets or practices to address equity
- ❑ Identified how BCAs can be used to address equity

Questions/Discussion on Energy Equity

How to Quantify DER Impacts for Benefit-Cost Analyses

An Overview

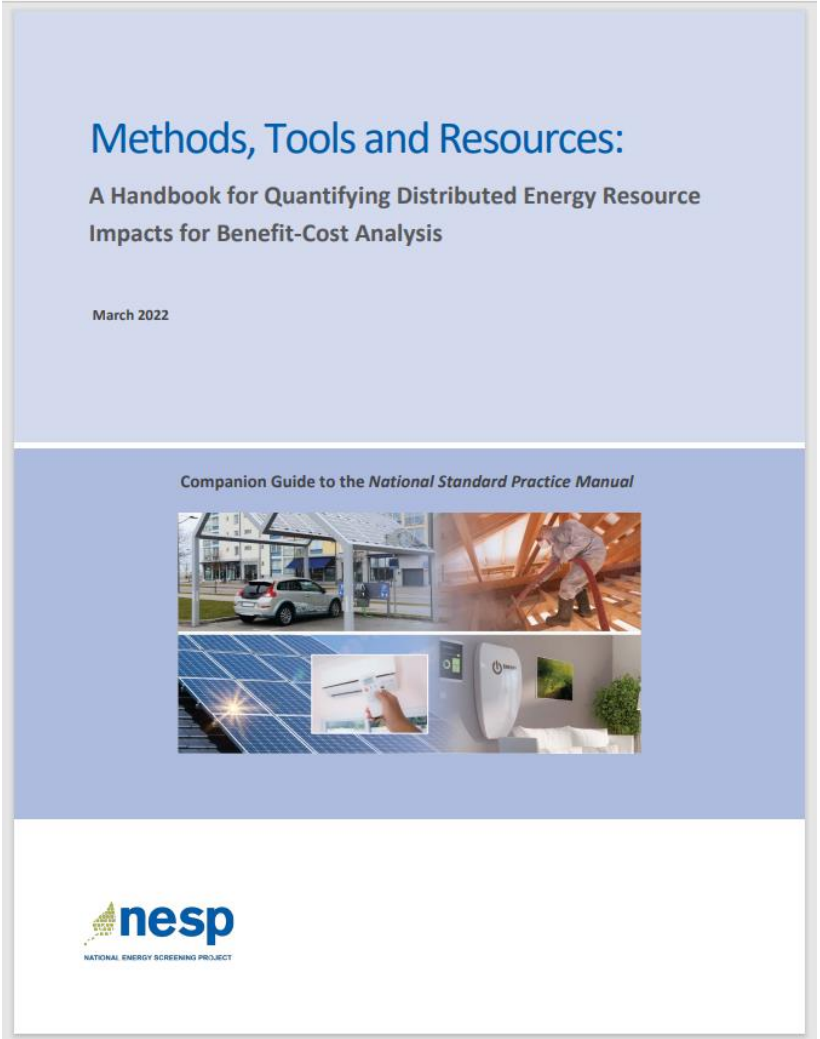
NSPM Handbook for Quantifying DER Impacts

The NSPM provides guidance on how to develop primary and secondary BCA tests.

The MTR Handbook provides guidance on how to determine the inputs to those BCA tests.

Contents:

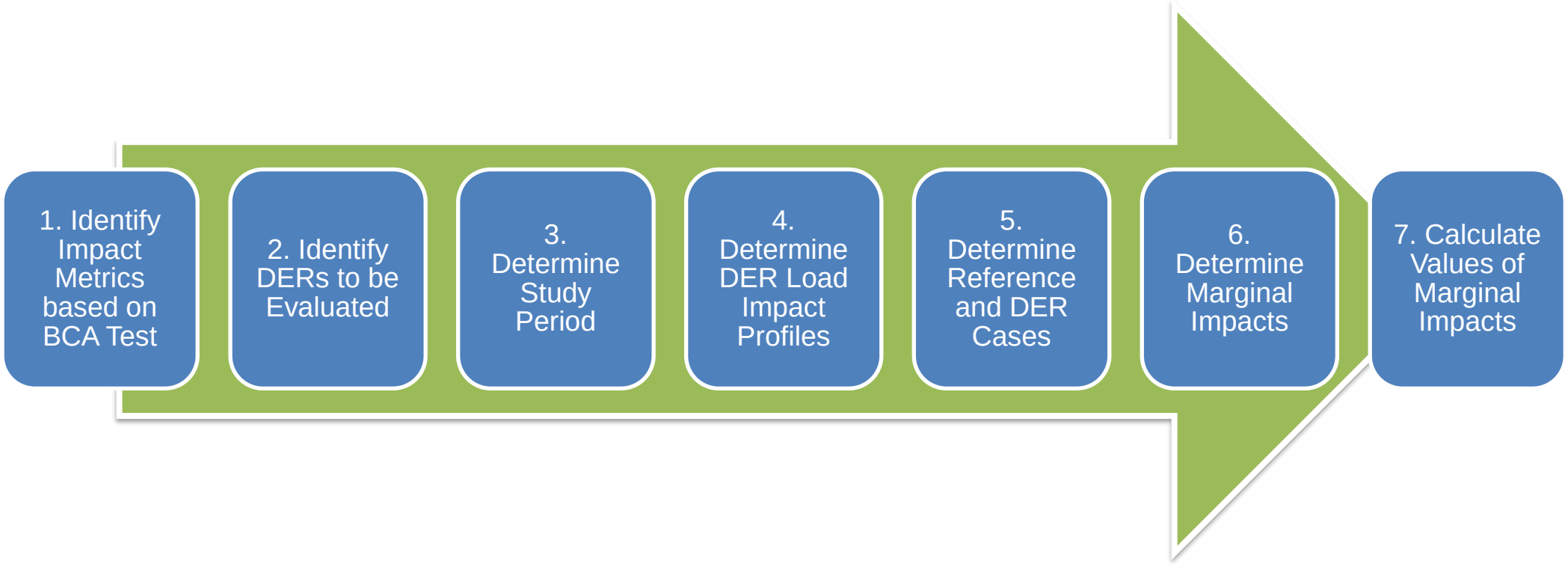
- Key Components to Calculate BCA Impacts
- Electric Utility System Impacts
- Gas Utility System Impacts
- Other Fuel System Impacts
- Host customer Impacts
- Societal Impacts
- Reliability & Resilience
- Energy Equity
- Uncertainty & Risk
- Load Impact Profiles



Available from:
https://www.nationalenergyscreeningproject.org/resources/quantifying-impacts/

Key Components to Calculating DER Impacts

Once a jurisdiction has defined its BCA test and the impacts to be accounted for, there are multiple steps necessary to calculate the impacts to input in a BCA:



Develop Reference and DER Cases

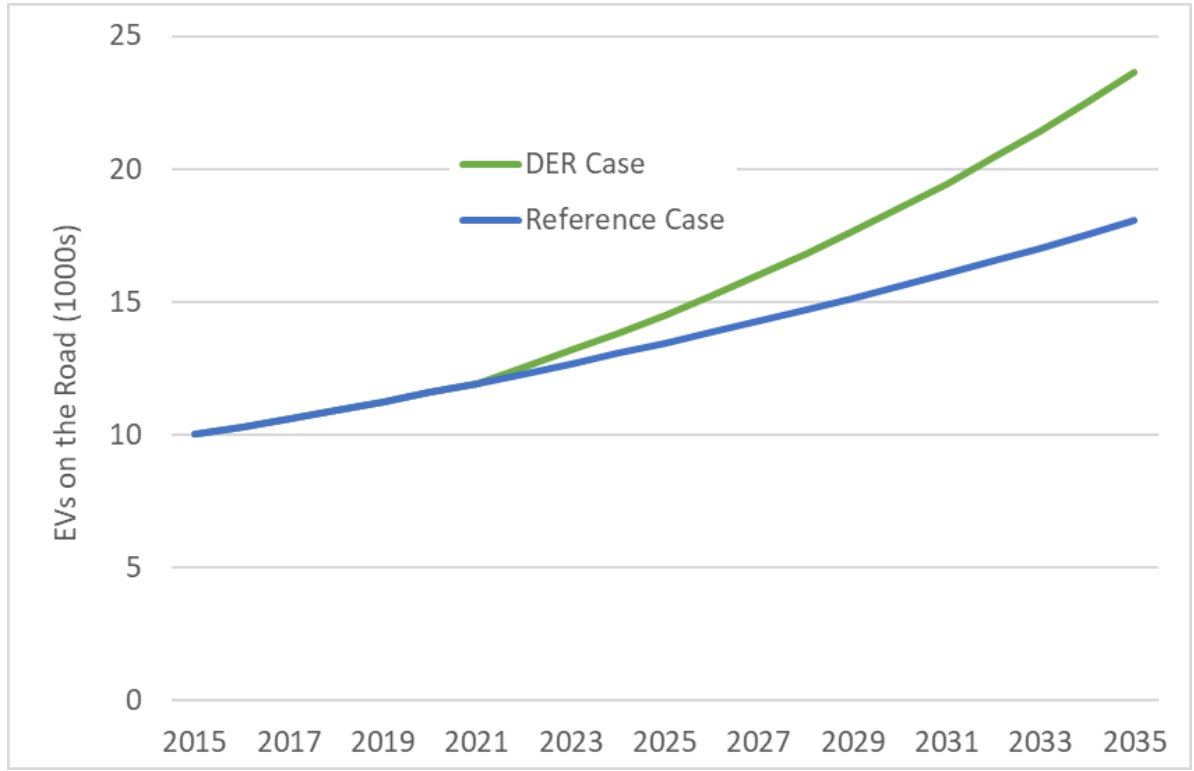
Determining BCA impacts entails comparing two scenarios:

- **Reference Case:** without the proposed DERs
- **DER Case:** with the proposed DERs.

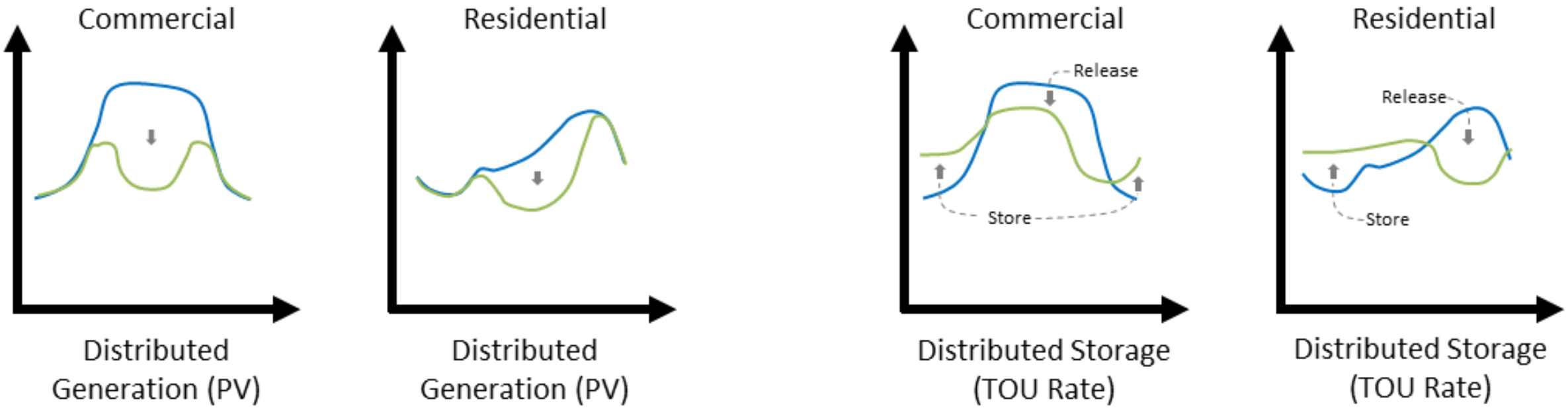
Difference between two cases indicates *the marginal impacts* of the DERs in the DER Case.

Reference Case - based on the most likely forecast of customer demand and utility resources to meet that demand - absent DERs being evaluated in the BCA.

DER Case - includes DERs being evaluated and reflects modified customer demand and utility resources needed to meet that demand.



Determine Load Impact Profiles



Reference Case Load Profile

DER Case Load Profile

Marginal versus Average Costs (Impacts)

Average costs: the cost of producing a product divided by the number of products produced.

Marginal costs: the change in per-unit costs as the result of a small change in output.

BCAs should use marginal impacts because they capture the incremental effects of adding DERs to the system

	Average impacts	Marginal impacts
Annual electric energy cost ($/MWh)	total variable energy costs (in $) / total energy production (in MWh)	change in the annual energy costs (in $) as the result of a small change in energy demand (e.g., one kWh)
Annual electric generating capacity cost ($/kW-year)	total generation capacity cost (in $) / total capacity provided (in kW-year)	change in annual capacity costs (in $) as the result of a small change in peak demand (e.g., one kW)
Annual gas production cost ($/MMBtu)	total gas cost (in $) / total annual gas production (in MMBtu)	change in annual gas costs (in $/MMBtu) as the result of a small change in gas demand (e.g., one MMBtu)

Long-Run versus Short-Run Marginal Costs

Short-run costs - These costs occur before capital investments are made to increase production capacity.

- Short-run marginal electricity costs include the fuel, O&M, labor and other expenses that are incurred to produce electricity without requiring additional investments in new generation, transmission, or distribution capacity.

Long-run costs - Based on premise that all costs are variable over the long-run. Long-run costs include short-run costs plus all the capital investments needed to increase production capacity over the study period.

- Long-run marginal electricity costs include all short-run marginal impacts plus the costs associated with new generation, transmission, and distribution capacity investments.
- Long-run costs should also account for any reductions in capacity, such as the retirement of existing generation, transmission, and distribution facilities.

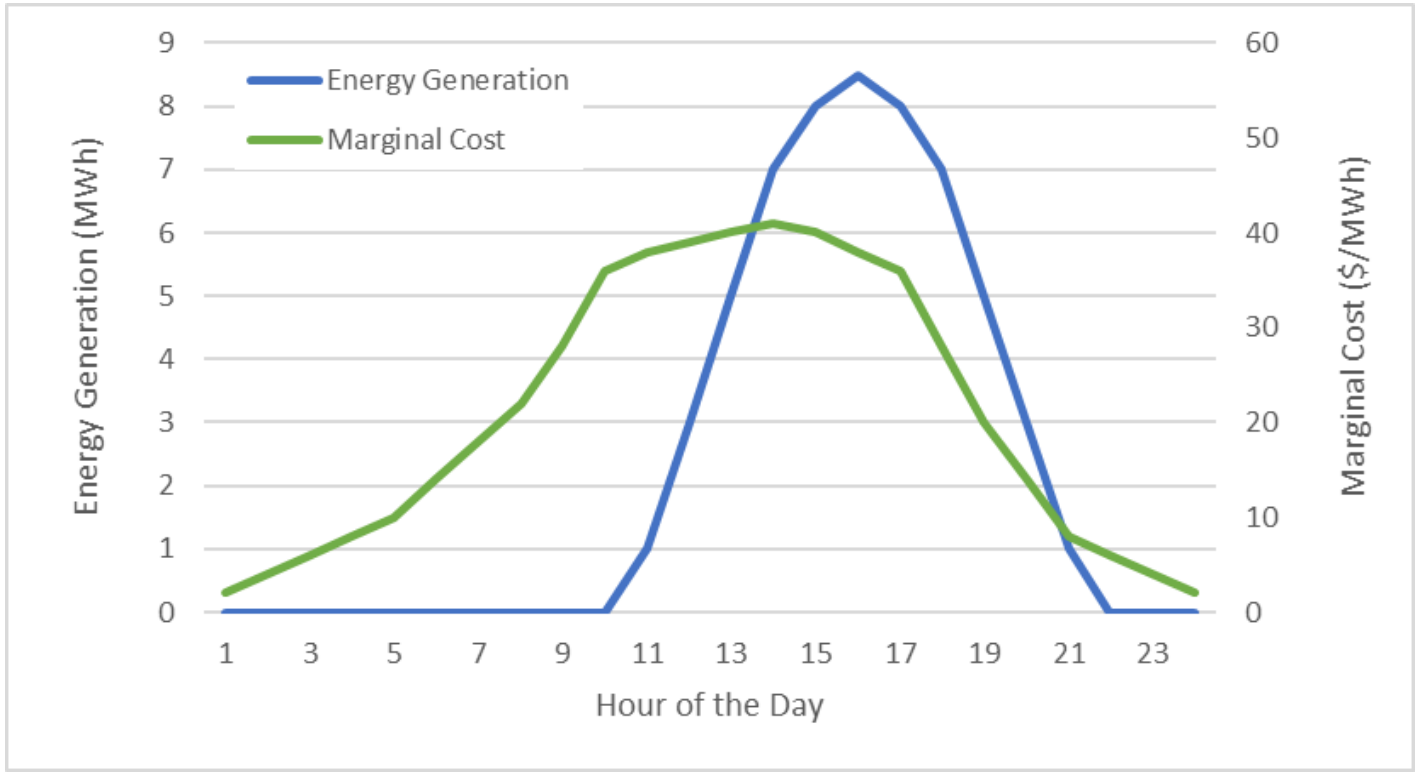
<u>BCAs should use long-run marginal costs</u> because DERs can potentially postpone or avoid capacity costs that are not included in short-run costs.

Mapping Load Impact Profiles Onto Marginal Costs

The blue line represents the hourly “load impact profile” of a distributed PV technology.

The green line represents the hourly marginal generation cost on the electricity system.

It is important to map the load impact profile onto the marginal cost, for each hour.



Key Steps for Calculating Values of DER Impacts

Step	Calculation	Electric Energy	Electric Capacity	Gas Energy	Reliability
1. Identify Impact Metric(s)	Determine based upon type of impact	MWh	kW	MMBtu	SAIDI & SAIFI
2. Determine DER Load Impact Profiles	Determine based upon DER type and use case	MWh	kW	MMBtu	kW, MMBtu
3. Develop Reference Case	Calculate the magnitude and value of relevant metrics	$ and MWh	$ and kW	$ and MMBtu	$ and hours of outage time
4. Develop DER Case	Calculate the magnitude and value of relevant metrics	$ and MWh	$ and kW	$ and MMBtu	$ and hours of outage time
5. Determine Marginal Impact	Calculate the difference between DER and Reference Cases	$/MWh	$/kW	$/MMBtu	$/hour
6. Calculate Dollar Values	Map marginal impact onto load impact profile	$	$	$	$

Develop Methodologies and Inputs to Account for All Relevant Impacts
(Including Hard-to-Quantify Impacts)

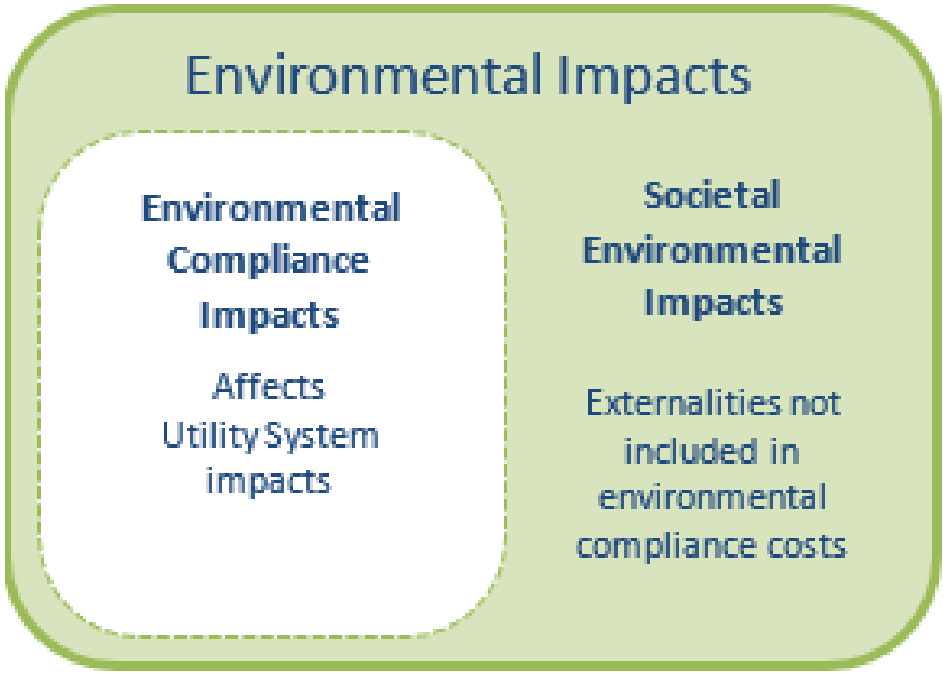
Approach	Application
Jurisdiction-specific studies	Best approach for estimating and monetizing relevant impacts.
Studies from other jurisdictions	Often reasonable to extrapolate from other jurisdiction studies when local studies not available.
Proxies	If no relevant studies of monetized impacts, proxies can be used.
Alternative thresholds	Benefit-cost thresholds different from 1.0 can be used to account for relevant impacts that are not monetized.
Other considerations	Relevant quantitative and qualitative information can be used to consider impacts that cannot or should not be monetized.

Environmental Compliance Costs versus Societal Environmental Costs

- Environmental compliance impacts are the direct impacts that will be incurred by the utility and passed on to all customers.
  - Example: cost of pollutant allowances.
- Societal environmental impacts are “externalities” that are not directly paid for by utilities or customers.

This distinction is very important:

1. All BCA tests should include environmental compliance impacts, but societal environmental impacts should only be included in a BCA test if consistent with jurisdiction’s energy policy goals.
2. Environmental compliance impacts will affect customer rates and bills, but societal environmental impacts will not.



Estimating Environmental Compliance Impacts

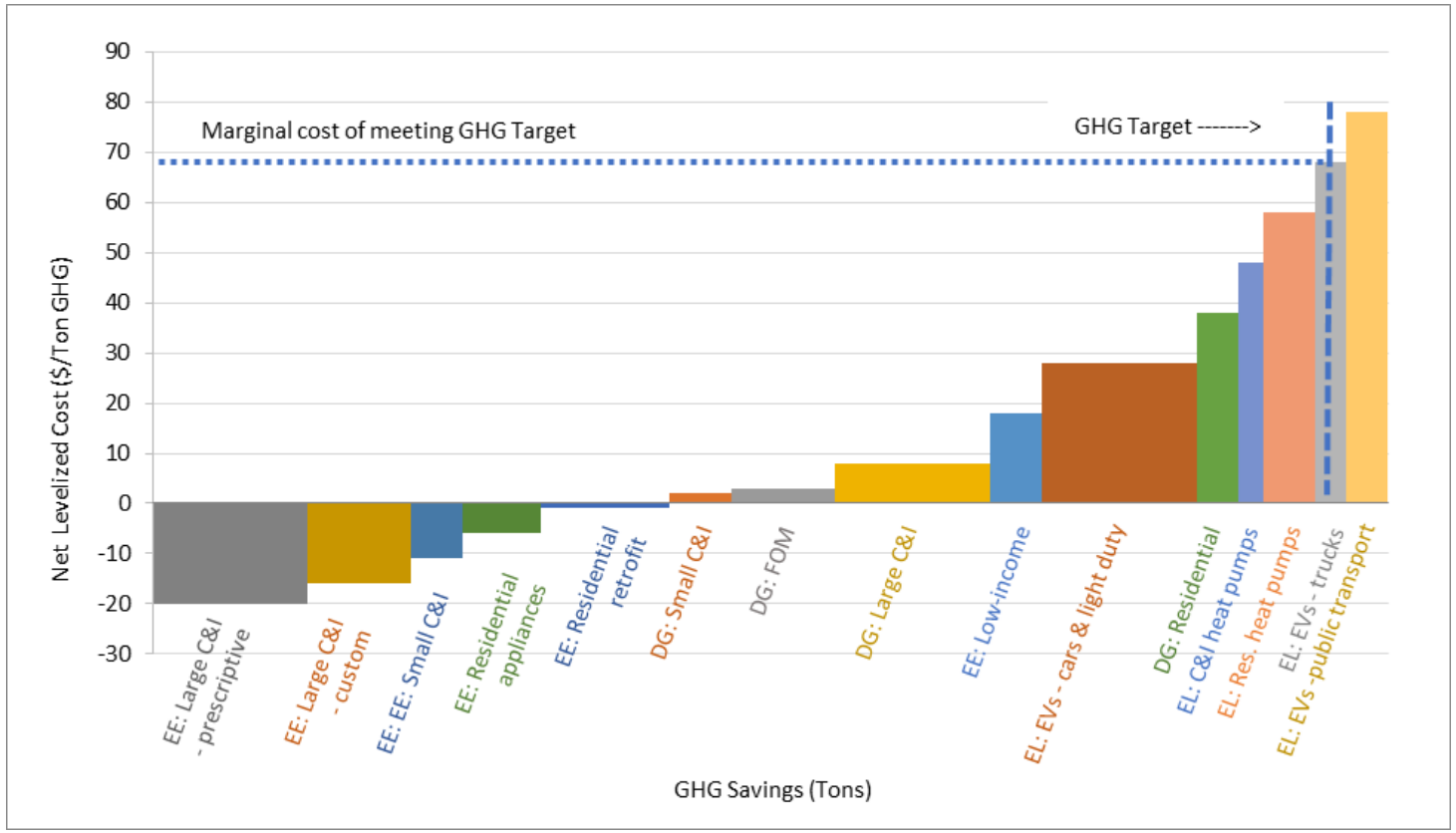
Marginal abatement cost (MAC) method:

Based on identifying the abatement option that is likely to be the *marginal option* needed to meet an environmental target.

MAC curve can be used to show net levelized cost of all the abatement options

- Sorted from lowest to highest cost, where last option needed to meet the environmental target is the marginal abatement option.
- Last option represents the cost of meeting the target i.e., MAC is $68/ton of GHG

This method can also be used to estimate *societal* environmental impacts, but this requires a societal GHG goal, e.g., net zero GHG emissions by 2050.



Estimating Societal GHG Impacts

Social Cost of Carbon

- Uses a “damage cost” approach for determining the total cost to society of GHG emissions.
- Accounts for all damages from climate change, such as:
  - Agricultural productivity; human health effects; property damage from floods, fires, and other natural disasters; risk of political conflicts; impacts on ecosystems; disruptions to energy systems; environmental migration; etc.
- Since 2008 the US Interagency Working Group (IWG) has produced estimates of the SCC
  - Most recent values are from 2021.
  - IWG now produces a social cost of methane and a social cost of nitrous oxides.
- IWG SCC considered a credible source based on expertise of agencies involved, but is sensitive to many factors, each of which is highly uncertain:
  - Choice of models; damage functions used; forecasts of population growth; macroeconomic development; climatological changes; and more.
- The SCC models impacts out to the year 2300 (i.e., a forecast of 278 years)
  - Consequently, choice of discount rate has a large impact on the results.

Quantifying GHG: SCC versus MAC Methods

Method	Description	Applications	Advantages	Disadvantages
Social Cost of Carbon (SCC)	Based on future global damage costs from climate change	1. For determining the societal cost of GHG emissions 2. For determining the cost of compliance with GHG mandates that require meeting a societal GHG goal, e.g., net zero emissions by 2050	• Values are readily available • Values are credible because they were developed and vetted by global experts and federal agencies • Can be applied to emissions from any sector • Does not require a specific carbon reduction target	• Involves considerable uncertainty and debate about future damage costs • Value is extremely sensitive to the discount rate chosen and complex modeling assumptions • Can only be used to determine total social cost of GHG emissions
Marginal Abatement Cost (MAC)	Based on cost of technologies and other options that can be used to abate GHG emissions to a desired level in the jurisdiction of interest	1. For determining the societal cost of GHG emissions, if a societal GHG goal is used, e.g., net zero emissions by 2050 2. For determining the cost of complying with specific GHG targets	• Well-suited for determining the cost of compliance with GHG targets that are less stringent than a societal GHG goal • Based on known technologies with known costs relevant to the jurisdiction • Reveals the actual costs that might need to be incurred to meet GHG target	• Requires concrete emission abatement targets • Values not easily available; estimates are complex and resource-intensive • Ideally requires analysis for multiple sectors (electric grid, building, transportation, industry)

Poll #3: Which of the DER impact categories below do you think are the most challenging to quantify? (pick up to three)

- ❑ Avoided electricity costs
- ❑ Avoided natural gas costs
- ❑ Reliability and resilience system impacts
- ❑ Host customer: energy impacts
- ❑ Host customer: non-energy impacts
- ❑ Societal: GHG emissions
- ❑ Societal: public health impacts
- ❑ Societal: macroeconomic impacts

Questions/Discussion on Quantifying Impacts

Recap of 3-day Training

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- Key categories and inputs to BCA
- Foundational BCA principles and using a BCA framework

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- Developing a primary cost-effectiveness test
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Thank you!

And any closing questions?