Key Considerations for Managed EV Charging Benefit-Cost Analysis

PRESENTED BY

Sanem Sergici
Goksin Kavlak

PRESENTED FOR

DOE EVGrid Assist Technical Advisory Group

10/17/2024

Brattle

Agenda

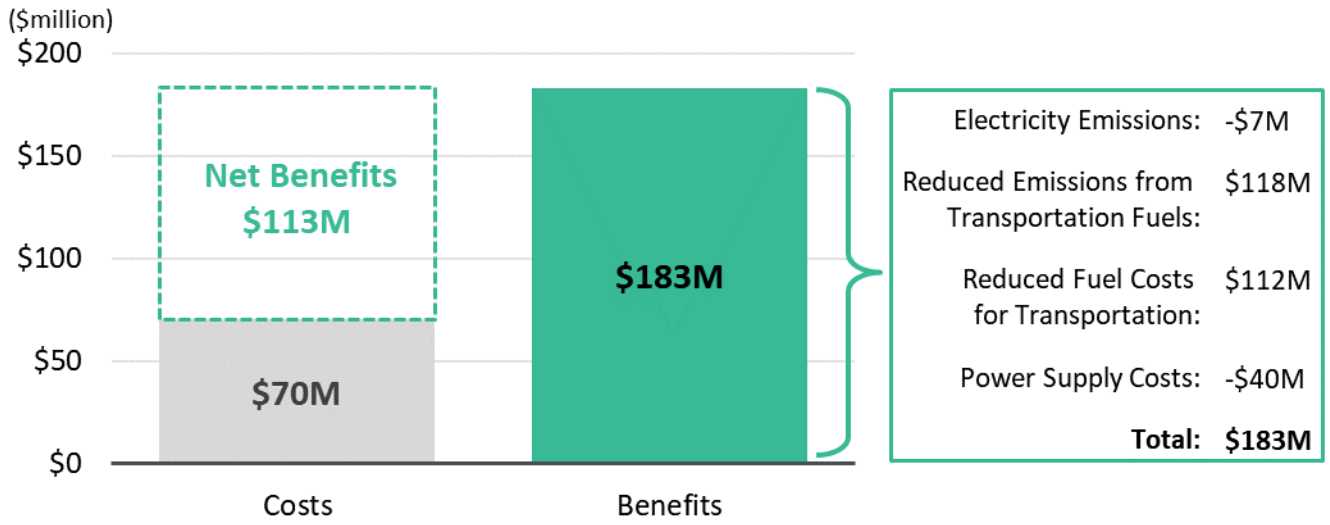
- Brattle's BCA framework
- Key considerations for managed EV charging BCA
- Recent Brattle BCA applications

Benefit-Cost Analysis of Utility Programs

Brattle has been conducting benefit-cost analyses (BCA) of transportation electrification programs (including managed charging) by applying jurisdiction-specific frameworks and relying on its expertise in EV modeling

Clients	BCA Scope
Pepco, DC	Climate Solutions 5-Year Action Plan, Jan 2022 Filing
Pepco, DC	Transportation electrification programs in Climate Solutions Plan Phase I Application, Oct 2022
Pepco, MD	Transportation electrification programs in Multiyear Rate Plan, May 2023
BGE, MD	Transportation electrification programs, May 2023
BGE, MD	School Bus Electrification V2G 2023
Xcel Energy, CO	Xcel Energy Transportation Electrification Plan 2.0, 2023

Example: Benefits and Costs of Pepco DC Transportation Electrification Portfolio



Benefit-Cost Analysis of Utility Programs: Managed Charging

- As part of the BCA, we analyzed a range of programs including both active and passive managed charging such as:
  - Active managed charging programs
  - Whole-house TOU rates
  - EV-only TOU rates
  - Off-peak charging incentives
  - Vehicle-to-grid (V2G) programs

- While different programs include different inputs and assumptions, we employ a unifying framework (next slide)

Managed Charging BCA Framework

- Total program budget, including participant incentives and cost of equipment, if any
- Estimated by utility at the program level for programs analyzed in the BCA

- Establish estimates of marginal system costs (e.g., energy, capacity) and emissions costs (e.g., social cost of carbon)
- Combine with system impacts from **STEP 3** to produce value of system impacts

- **STEPS 1 through 5** are repeated using high and low estimates for key drivers of the results, to account for uncertainty in the projections

- Based on enrollment targets and program duration
- May include adjustments to reflect retention and change in behavior over time

- For each program, estimate per-participant energy system impact (e.g., kWh, kW) and emissions impact (e.g., tons of CO_2)
- Combine with participation estimates from **STEP 1** to produce system impact estimates

- Energy system and emissions value from **STEP 4** is compared to program costs from **STEP 2** to produce cost-effectiveness metrics (e.g., benefit-cost ratio, NPV)

Costs and Benefits

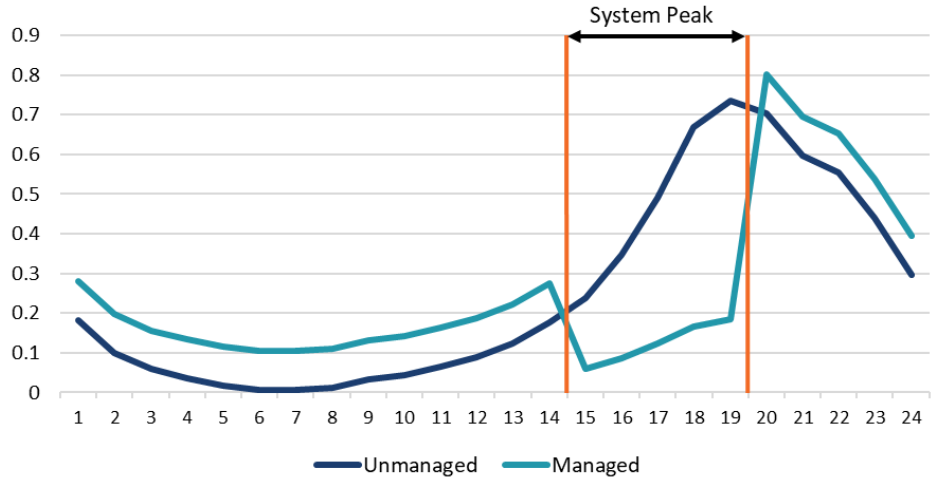
- Despite using different mechanisms, all programs aim to provide system benefits, i.e., reduce energy, capacity, and T&D costs, as well as environmental impacts in exchange for program incentives and costs
- Costs and benefits depend on the specific test adopted in a jurisdiction, but generally fall under the following categories:

Costs	• Utility program costs • Utility incentives • Equipment costs – if coupled with managed charging • Decreasing utility revenues (in ratepayer impact test)
Benefits	• Avoided electricity generation costs • Avoided generation capacity costs • Avoided T&D capacity costs • Avoided grid GHG emissions costs • Wholesale capacity price impacts (also known as DRIPE)

Calculation of Benefits

Benefits	Description
Avoided electricity generation costs	Impact of load shift on the cost of generating electricity. Estimated by projections of hourly wholesale electricity generation prices and load shift. Typical Data Sources: Near-term energy future prices from S&P, long-term projections of wholesale prices from NREL Cambium, managed and unmanaged load profiles from NREL EVI-Pro Lite
Avoided generation capacity costs	Impact of changes in electricity peak demand on the costs of generation capacity. Typical Data Sources: Capacity prices from RTO auction results and NREL Cambium, RTO reserve margin, load profiles, system peak
Avoided T&D capacity costs	Impact of changes in electricity peak demand on T&D system capacity costs to maintain system reliability. Typical Data Sources: Marginal distribution cost estimations developed by utilities/Brattle or state DSM filings, load profiles, system peak

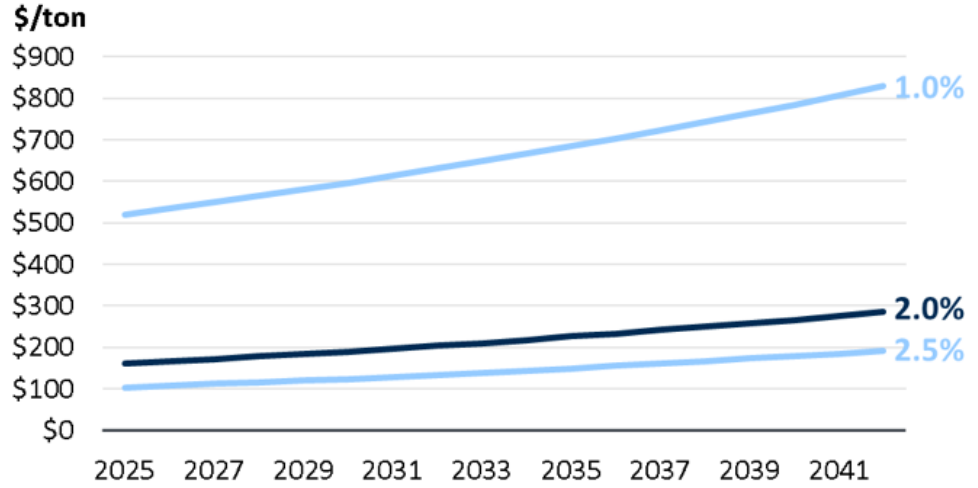
Example: Managed and Unmanaged Load Profiles



Calculation of Benefits

Benefits	Description
Avoided grid GHG emissions costs	Societal costs of avoided GHG emissions due to load shift. Estimated using societal cost of carbon (SCC) and change in hourly marginal emissions due to load shift. Typical Data Source: SCC projection from U.S. Interagency Working Group, historical emission rates from RTO, long-term marginal emission rate projections from NREL adjusted for future renewables adoption
Wholesale capacity price impacts	Changes in wholesale generation capacity prices and costs due to the change in electricity peak demand. Typical Data Source: Technical reports and state sources such as Maryland EmPOWER in competitive wholesale markets

Social Cost of Carbon under Various Discount Rate Assumptions



Sources: NYSERDA and RFF; Interagency Working Group on Social Cost of Greenhouse Gases

BGE School Bus Electrification Benefit-Cost Analysis (1/2)

Brattle conducted benefit-cost analysis with a focus on V2G benefits of school bus electrification

- ***Base Benefits without V2G***: Avoided fuel costs, avoided fuel emissions, avoided maintenance costs, and resilience benefits, net of incremental power system costs and emissions
- ***Benefits with V2G***: Incremental power system benefits of operating buses as V2G resources, including avoided energy & AS costs, avoided generation capacity costs, avoided T&D costs, and avoided GHG emissions
- ***Costs***: Incremental electric school bus costs, charging infrastructure costs, and other program implementation costs

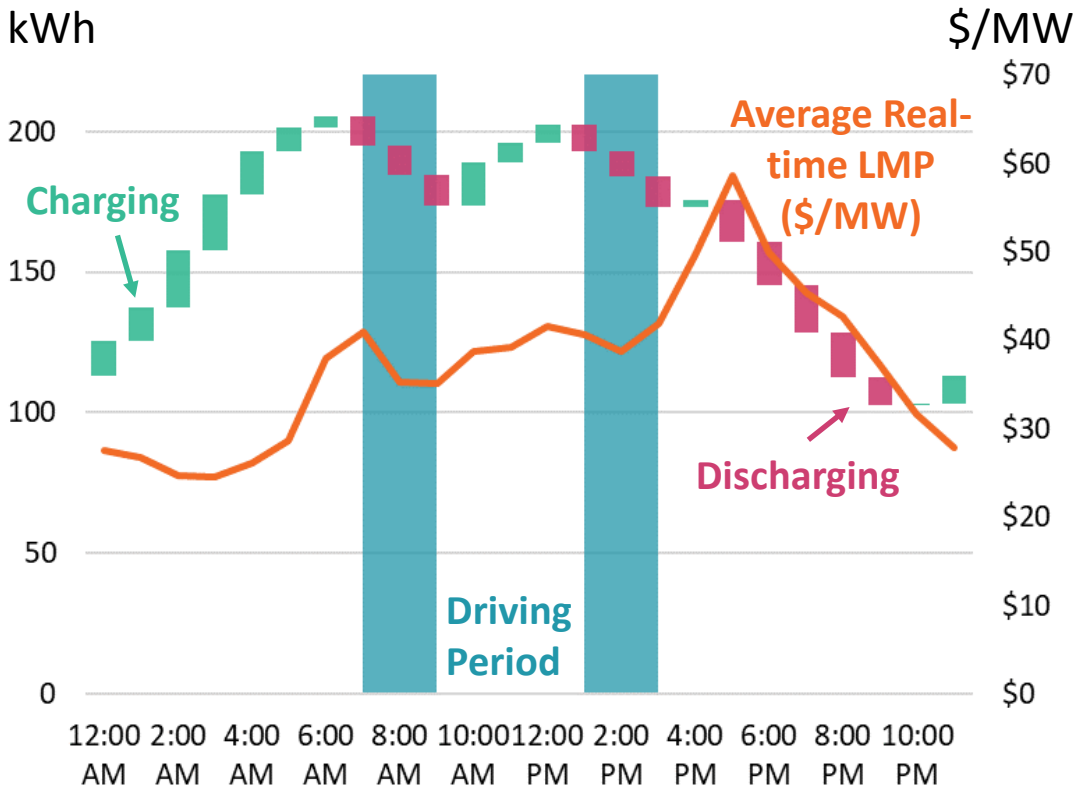
BGE School Bus Electrification Benefit-Cost Analysis (2/2)

V2G modeling includes developing charge-discharge profiles and energy market participation

- Buses as stationary storage assets, charging during low price hours and discharging during high price hours
  - Charges to full capacity between overnight to take advantage of low prices
  - Is forced to discharge during driving hours as it moves along its route
  - Discharges during the evening during high price hours
- Participating in energy markets to earn energy and A/S revenues
- As an additional constraint buses must drive during the morning and afternoon discharging off the grid and unavailable for energy market participation

2020-2022 Average Daily Storage Level (kWh)

60kW Charger/212kWh Bus (Energy Only)



Key Considerations for Managed Charging BCA

Key Considerations

Based on our previous BCAs, we have identified several important considerations in conducting BCAs for managed charging programs

These considerations are related to capturing program design parameters, choosing BCA parameters, and other methodological issues

These key considerations affect the robustness of the BCA results

Key Considerations: Program Design Parameters

Program size and scope

- Programs with a small number of participants (e.g., pilot scale programs) may appear less cost-effective due to their small number of participants leading to smaller grid benefits and larger start-up costs. However, they lead to valuable learnings that may not be easily quantified in a BCA

Program duration

- Benefits are affected by duration of program, i.e., how long participants are expected to maintain load shifting
- Especially important when modeling passive managed charging (off-peak charging incentives and TOU rates). In such cases, we modeled load shifting through the life of an EV, e.g., 12 years. Also modeled participant attrition and reduction in load shifting over time

Program costs

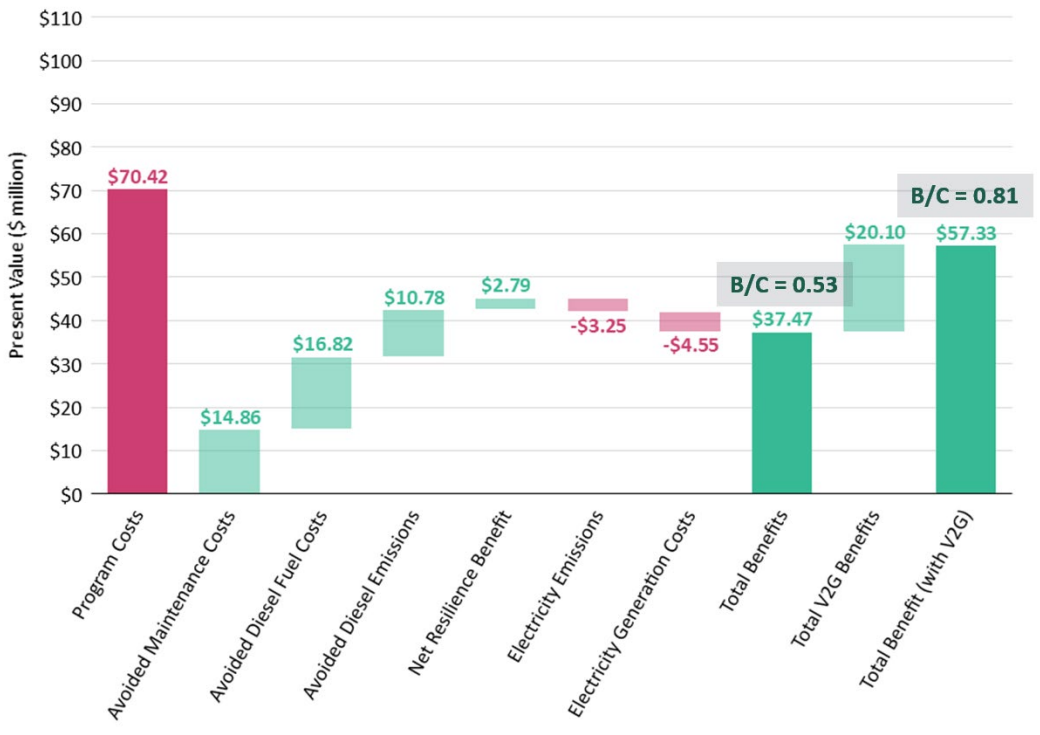
- Upfront costs such as IT costs may dwarf the system benefits in the near term. However, such investments may be beneficial for a wide range of programs in the future, and their costs can be allocated to multiple programs

Key Considerations: Participant Characteristics

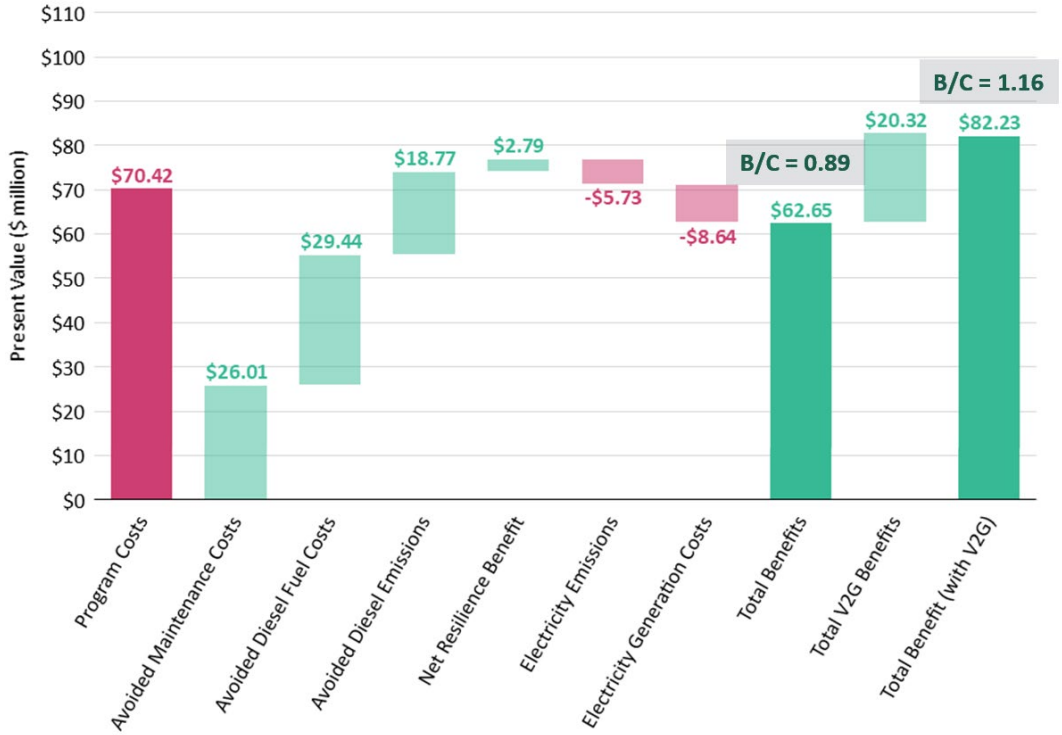
Participant load size

- Participants with larger flexible loads (e.g., larger battery) can lead to larger system benefits
- Programs targeting those participants as opposed to “average” driver may lead to higher B/C ratios

80 Miles per School Day



140 Miles per School Day



Key Considerations: Choice of BCA methodology

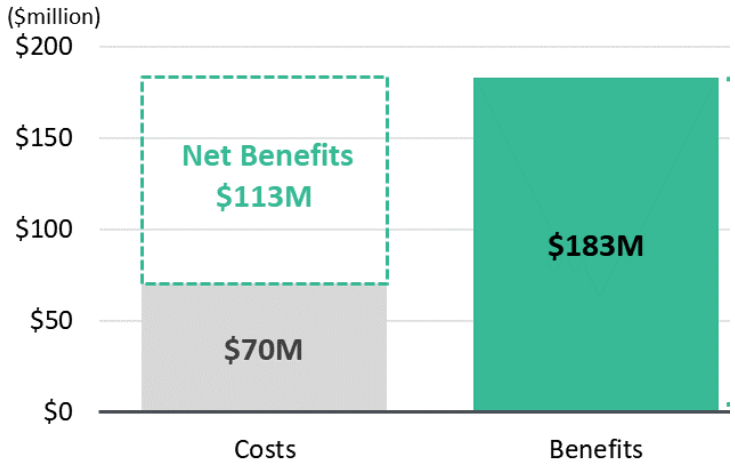
Cost-effectiveness test

- Some jurisdictions specify the tests to be used in the BCA, e.g., Maryland jurisdiction-specific test
- In other cases, we develop the tests by adapting established test structures such as the societal cost test
- Benefits and cost categories depend on the test. Also, in restructured vs. non-restructured markets, accounting of distribution and supply-related costs and benefits may differ based on the test (e.g. utility cost vs participant cost test)
- SCT boundary is set around the states. Federal incentives are usually included as benefits

Reporting results

- Results can be summarized for each program separately and for the portfolio as a whole. We usually report both
- Portfolio may contain programs modeled as 'cost-only' (e.g., technical assessments) although they provide synergistic benefits
- Commonly used metrics are B/C ratio and net present value

Example: Present Value of Benefits and Costs



Key Considerations: Choice of BCA parameters

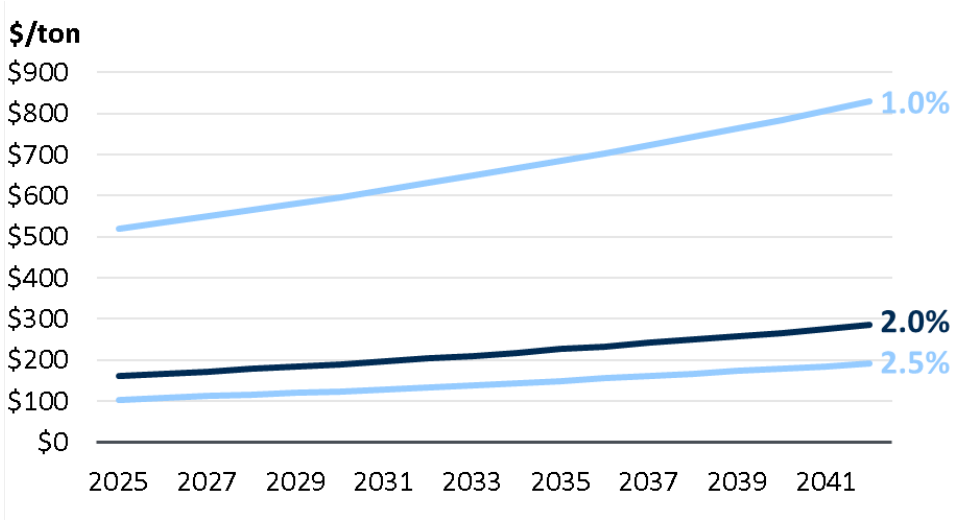
Discount rate

- The discount rate should be consistent with the perspective of the BCA test (societal vs company)
- Discount rates also depend on the factor being measured. For example, for social cost of carbon, societal discount rates are used; these typically vary in the range of 1-3% in real terms
- For consistency, the same societal discount rate should be used when measuring all societal factors

Time horizon

- The time horizon of the BCA should allow the ongoing benefits and costs to be realized over time and included in the BCA as well as the upfront costs
- Covering the useful life of equipment and other infrastructure provided as part of the program is important

Projected Social Cost of Carbon



Source: New York State Energy Research and Development Authority and Resources for the Future. "Estimating the Value of Carbon: Two Approaches." April 2021.

Key Considerations: Input Data

Choice of data sets

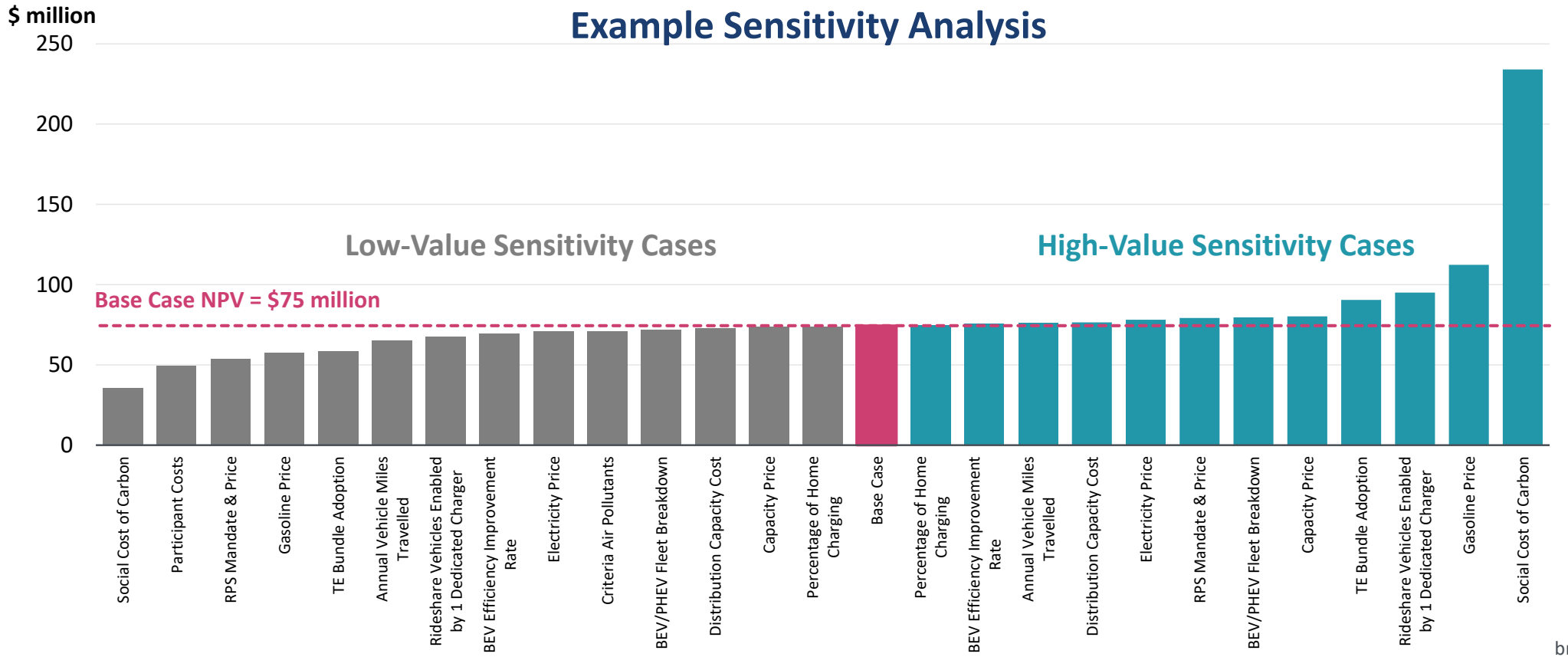
- BCA incorporates multiple data sets, e.g., social cost of carbon, emissions factors, and technology cost projections, region-specific weather data, regional driving patterns
- Using an internally consistent view of data such as market prices is important. For example, forecasts of capacity prices should come from the same source as forecasts of wholesale electricity prices. Forecasts of market prices usually reflect a particular scenario about the future where prices are determined in an interrelated way
- Reputable sources should be used and referenced. In some states, BCA guidelines specify the data sources to be used. It is important to refresh the analysis with most up-to-date data available

(Continued on the next slide)

Key Considerations: Input Data

Choice of data sets (Continued)

- Sensitivity analysis identifies the key parameters the model is most sensitive to, and how results may vary due to uncertainty



Key Considerations: Unquantified Benefits

Qualitative assessments to supplement BCAs

- Qualitative assessments can supplement BCAs to inform future program design
- Small-scale programs which do not appear cost-effective in the near term may offer other benefits such as learning opportunities for future large-scale deployment
- Certain strategies, such as those that encourage electrification in disadvantaged communities, may lead to lower benefit to cost ratios. This is due to higher incentive costs aiming to cover a larger-share of the customers' costs, which may be justified to achieve environmental justice goals

Recent Brattle BCA Applications

Recent Brattle BCA Applications on Transportation Electrification

Adoption Modeling (LDV/MDV/HDV)

Types of Analyses:
- In-house econometric EV adoption model providing state-level EV sales forecasts
- System-dynamics based module capturing the supply side drivers of EV sales such as increasing model availability, charging infrastructure and improved R&D activities

Clients:
- BGE, Com Ed, PGE, SRP, ERCOT

System & Substation Grid Impacts

Types of Analyses:
- EV load impact analysis under managed and unmanaged scenarios and impacts on utility ratemaking, infrastructure investments and other financial metrics
- Substation-level EV forecasts based on socioeconomic criteria

Clients:
- PGE, BGE, ERCOT

Utility EV Program BCA

Types of Analyses:
- Jurisdiction-specific BCA frameworks for a wide range of utility programs including charger deployment incentives, time-varying rates, managed charging, and other

Clients:
- Pepco DC, Pepco MD, Xcel CO, BGE

EV Charging Rate Design

Types of Analyses:
- Residential EV charging time-of-use rate design, pilot management, EM&V studies
- High demand draw charging station rate design including time-of-use rates and other rates complying with state regulations

Clients:
- PSE, LIPA, Evergy, New Hampshire DOE

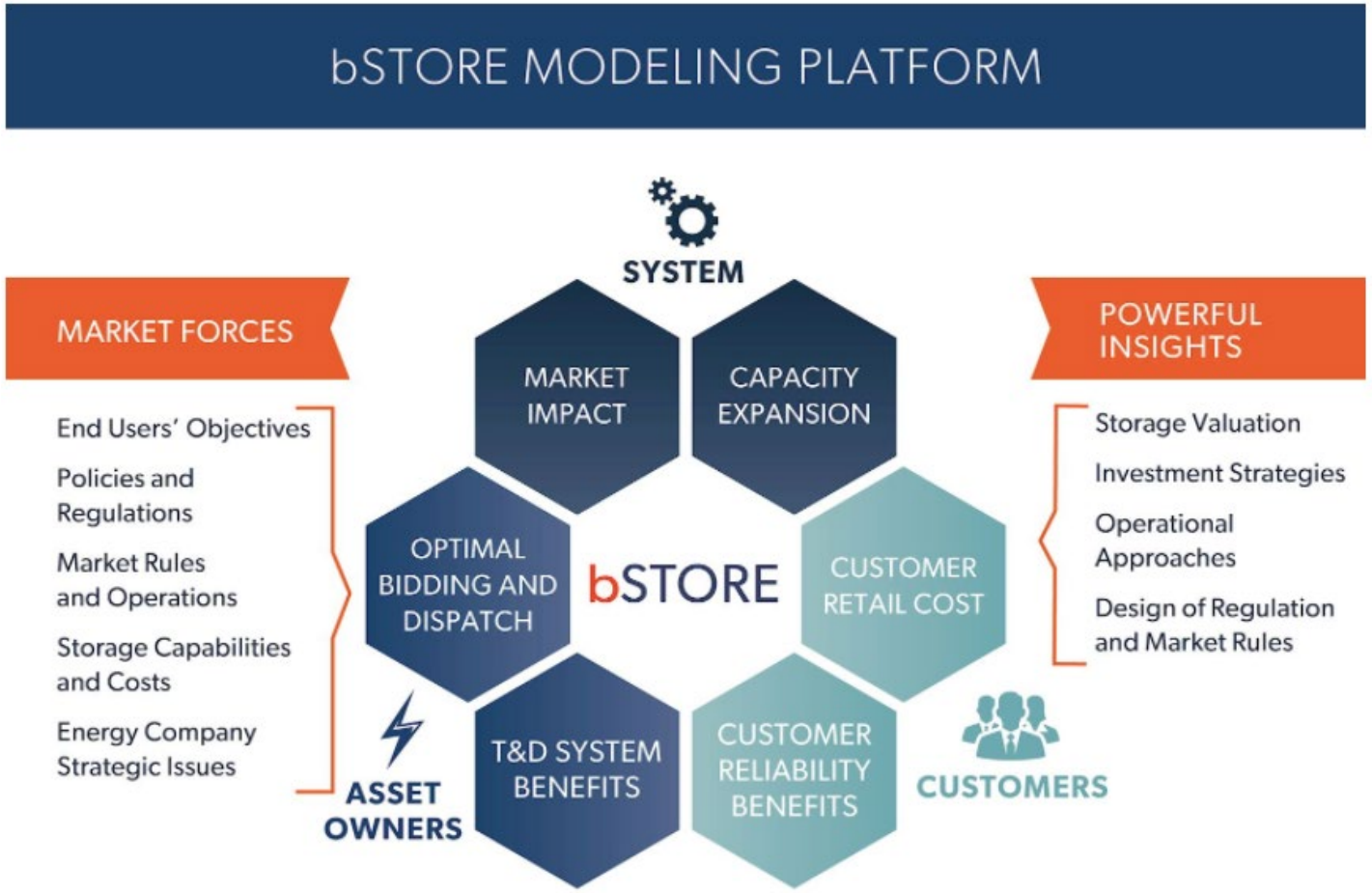
Managed Charging & V2G

Types of Analyses:
- Analysis of managed charging pilots to draw insight on system cost impacts and customer participation

Clients:
- BGE, SRP, Xcel CO

Appendix

bSTORE Model Features



bSTORE Optimal Bidding and Dispatch Module:

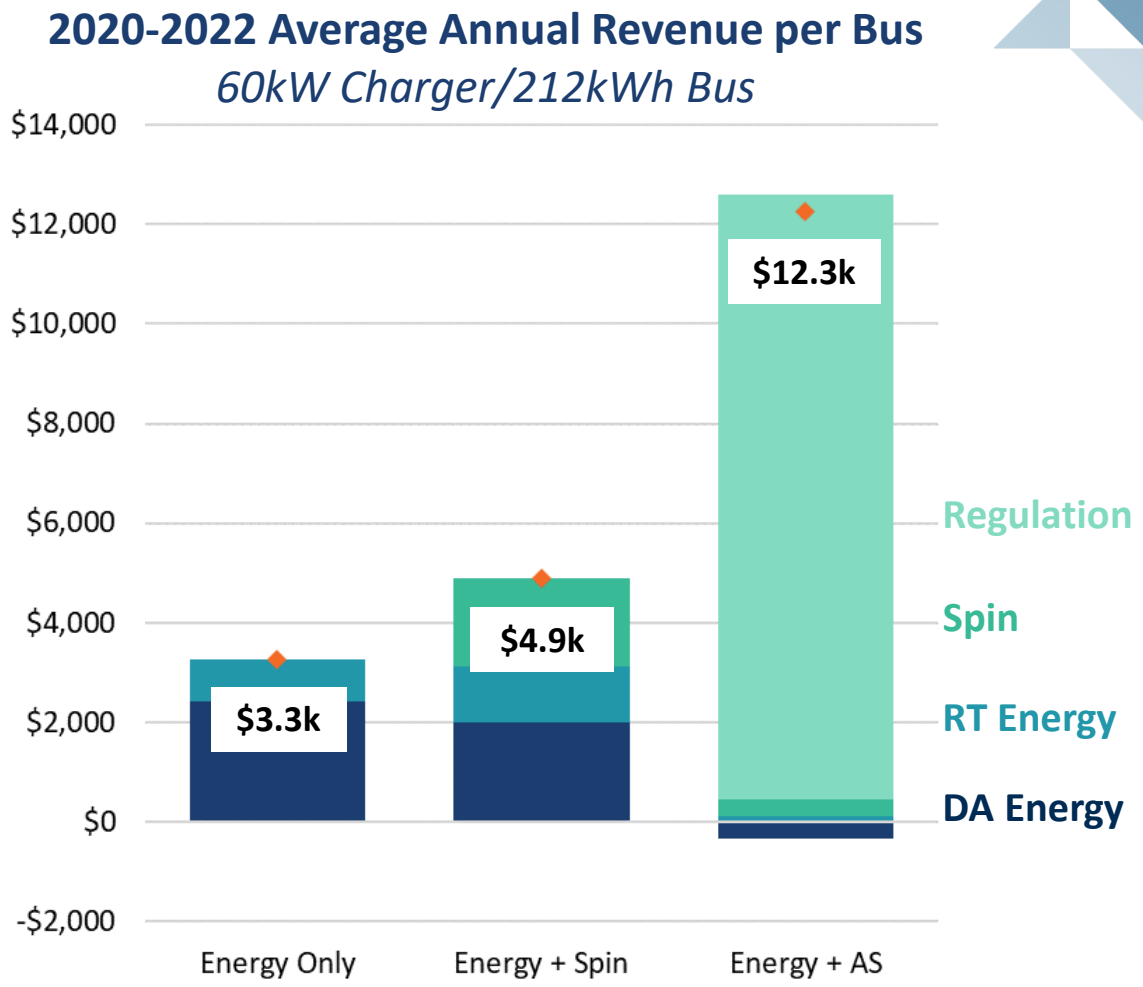
- Optimal bidding and scheduling strategies under real-world market conditions
- Maximize wholesale market value of storage assets through co-optimization of day-ahead energy, ancillary services, and real-time energy markets under uncertainty
- Co-optimized wholesale market value, distribution system value, and customer retail rate savings
- Optimized bidding and scheduling of "renewable generation+storage" assets

Market Participation Strategy

DA+RT Energy-only is a lower-bound on revenues that could be earned with a simple energy-oriented market participation strategy.

DA+RT Energy + Spin highlights the increase in value associated with participating in the ancillary service market.

DA+RT+A/S illustrates the significant revenue opportunity currently seen in the regulation market. These revenues are unlikely to remain at historical levels as battery capacity comes online and overwhelms the comparatively smaller regulation market



Note: 100kW configurations earn around 55% more revenue but the relationship between market participation strategies is comparable

Benefit Sensitivity Analysis

Input Assumption	Base Value	Sensitivity Value	80 VMT Case	140 VMT Case	190 VMT Case
Higher Diesel Fuel Prices	AEO Reference Case	AEO High Oil Price Case	+$10M	+$18M	+$26M
Higher Social Cost of Carbon	NY DEC	Proposed EPA Updates	+$5M	+$9M	+13M
Larger School Bus Cost Decline	3% per year	6% per year	+$2M	+$3M	+9M
Higher V2G Distribution Benefits	$30/kW-year	$90/kW-year	+$5M	+$5M	+$5M
Higher Air Pollutant Benefits	NHTSA Low Case	NHTSA High Case	+$0.4M	+$0.6M	+$0.8M

Clarity in the face of complexity

That's the Power of Economics™

Brattle