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California Public
Utilities Commission

Staff White Paper on Benefit-Cost Ratio Methodology

CPUC SENATE BILL 884 APPLICATION 26-02-005

April 10, 2026

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Executive Summary

Before 2022, the Commission assessed the cost-effectiveness of safety investments using a Risk Spend Efficiency (RSE) metric based on Multi-Attribute Value Functions (MAVFs) as discussed below.[1] The Commission moved on from this approach in D.22-12-027, noting RSE shortcomings:

> We concur with Staff that the RSE values produced by the MAVF approach have had limited utility. While the RSE values produced by the MAVF approach allow for comparison of the relative cost-effectiveness of various mitigation measures, the RSE values do not indicate whether the Benefits of a proposed mitigation measure outweigh its costs.[2]

The benefit-cost ratio (BCR) framework, the Commission adopted in D.22-12-027, quantifies the relationship between mitigation benefits and costs, integrating capital expenditures, operations and maintenance (O&M) costs and savings, and monetized risk reductions into a single cost-efficiency metric. As the Commission stated: "A Cost-Benefit Approach … will be more intuitively understandable and useful than utility computation of Risk and risk reduction scores, and RSE values, as required currently in the MAVF framework."[3]

The BCR framework the Commission developed in D.22-12-027 is not specific to wildfire and reliability risk; rather, it examines all utility risks, including those related to other safety issues. As the Commission stated in initiating its risk-based decision-making framework (RDF) rulemaking, all "risk events" are analyzed:

D.18-12-015 defines the concept of a "risk event" as "an occurrence or change of a particular set of circumstances that may have potentially adverse consequences and may require action to address," and states that "the occurrence of a risk event changes the levels of some or all of the attributes [consequences] of a risky situation."[4]

For wildfire mitigation, staff proposes refinements that preserve the original BCR framework developed in the RDF while adding greater detail and guardrails to support a more consistent and robust BCR metric for evaluating projects under Senate Bill (SB) 884 (Stats. 2022, Ch. 819) and A.26-02-005. This proposal address the following five objectives: (1) using a consistent

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[1] See D.16-08-018 and D.18-12-014.

[2] D.22-12-027 at 25-26.

[3] D.22-12-027 at 26.

[4] R.20-07-013 at 19;. See also D.22-12-007, Section 5.2 (listing all of the safety and reliability consequences the RDF framework was designed to address).

incremental baseline for evaluating wildfire mitigation projects aligned with RDF; (2) clarifying the treatment of O&M Costs and O&M Savings in BCR calculations; (3) comparing BCR formulations and identifying the most stable and consistent formulation; (4) application of the BCR framework to undergrounding and alternatives; and (5) provision of greater detail and transparency regarding BCR components. The Commission is faced with other issues in A.26-02-005, staff does not address those here.

This proposal examines three potential methods for a BCR calculation that will fulfill the five objectives and recommends adopting a formula, "Method3," that best meets those objectives. Method3 treats O&M Costs and O&M Savings separately, placing O&M Costs as a cost in the denominator and O&M Savings as a benefit in the numerator of the BCR.

1 Introduction

SB 884 requires the CPUC to consider multi-billion-dollar utility infrastructure investments for wildfire risk reduction and service reliability, all with direct ratepayer impacts. This proposal addresses utility proposals in this Application proceeding in the context of existing Commission SB 884 Resolutions SPD-15 and SPD-37 and the RDF's BCR framework. The proposal recognizes the need for a standardized, transparent, and economically sound framework to ensure these significant expenditures are just and reasonable, prudent, and cost-efficient. Utility investment in wildfire mitigation and in reducing Public Safety Power Shutoffs (PSPS) and reliability challenges is essential to prevent catastrophic losses of life, property, and service reliability, yet their immense costs raise complex questions about affordability, prioritization, and accountability. Consistent with the Commission's recent transition from RSE to BCR staff proposes refinements to establish a more robust and consistent BCR formulation for evaluating utility undergrounding proposals under SB 884.

Originally, the Commission adopted qualitative risk assessment requirements in the RSE to evaluate mitigation effectiveness. RSE measured risk reduction per dollar spent and relied on utility-defined MAVFs. The MAVF framework evaluated projects based on multiple attributes, such as safety, reliability, and cost, by assigning values to each attribute and combining them into a single score. Each attribute was weighted based on its importance, and project performance on each attribute was scored on a common scale. These weighted scores were then aggregated into an overall value score, enabling decision-makers to compare diverse projects.[5]

In moving from an RSE to a BCR approach, the Commission stated:

[5] Staff proposal on phase II, Rulemaking 20-07-013.

> [T]he change is warranted because the use of weights and ranges in the current MAVF approach has at times produced very high "implied [Values of Statistical Life] VSLs" in utility RAMP filings. For instance, the Staff Proposal states that recent [Risk Assessment and Mitigation Phase] RAMP filings contained implied VSLs of approximately $100 million. This amount is approximately ten times higher than any VSL contained in published in guidance documents across government and industry sources. The impact of an implied VSL of this level is that it makes certain Mitigations appear more beneficial than they would otherwise.[6]

The RSE's primary limitation was that it produced a unitless measure of cost-effectiveness that lacked a common reference point, making it difficult to interpret or compare across risks, projects, or utilities. For example, an RSE of 10,000 has no intrinsic meaning without knowing the scale or context of the risk scores used. Because each utility defines risk differently, RSE values were inconsistent and non-comparable. Because RSE does not express the numerator and denominator in a common domain, RSE cannot determine whether a mitigation's benefits exceeded its costs, thus limiting its effectiveness as a comprehensive cost-efficiency decision-making tool.[7]

To address these challenges, D.22-12-007 established the BCR as a central metric within its RDF proceeding.[8, 9] The BCR quantifies the relationship between mitigation benefits and costs by integrating capital investment, O&M Costs and Savings, and risk reduction into a unified monetized measure of cost-efficiency. Drawing from established economic evaluation standards, such as Office of Management and Budget (OMB) Circular A-94,[10] the U.S. Department of Transportation's Benefit-Cost Analysis (BCA) guidance,[11] and foundational academic work on cost-benefit analysis[12] the CPUC's BCR approach adapts classical benefit-cost analysis to the unique context of utility regulation, where the prudent use of utility investments and their impact on utility rates are evaluated alongside the potential consequences for public safety, reliability, and financial loss. The Commission found that such analysis could provide evidence of the reasonableness of utility-proposed safety mitigation while also taking into account ratepayer affordability. This staff proposal demonstrates that the specific

6 D.22-12-027 at 36.

7 M. Henrion, "Comparing the MAVF and RSE with the proposed Cost-benefit framework," August 2022.

8 CPUC Safety Policy Division, "Staff proposal on phase II Rulemaking 20-07-013," April 2022.

9 D.25-08-032.

10 Office of Management and Budget, "Circular No. A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," November 2023.

11 U.S. Department of Transportation, "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," May 2025.

12 A. Boardman, D. Greenberg, A. Vining and D. Weimer, "Cost-Benefit Analysis: Concepts and Practice," 2018.

methodological choices, particularly the treatment of O&M Costs and Savings and the baseline, are not minor technical details but high-stakes decisions that can systematically influence investment outcomes.

As the Commission found in D.22-12-007, the application of the BCR serves to provide a consistent, transparent, and replicable method for comparing mitigations across utilities and projects. Its primary purpose is to guide investment selection and prioritization, enhance regulatory oversight and decision-making, and protect ratepayer interests. To achieve these goals, however, the BCR must be applied consistently and built upon precisely defined components.[13, 14] This proposal examines these components in detail, comparing alternative formulations and highlighting the advantages and limitations associated with each approach.

First, this proposal outlines the evolution of benefit-cost assessment methodologies within benefit cost analyses used by the federal government and in CPUC proceedings. Next, it explores the conceptual foundations of BCR as a regulatory decision-making measure. Then, it addresses key methodological and policy considerations, including baseline treatment, and the integration of O&M Costs and Savings. Finally, this paper proposes that the CPUC add greater detail and guardrails to the BCR calculation, particularly for utility SB 884 applications, asserting that a well-defined BCR is a practical, transparent, and highly effective regulatory decision-making tool that, when properly designed and implemented, strengthens consistency, accountability, and regulatory oversight in utility risk planning and investment.

2 Background: Existing National and CPUC Benefit-Cost Analysis Framework

2.1 Existing National Benefit Cost Analyses

Staff propose that to be consistent and transparent, the Commission's SB 844 risk-assessment framework should be grounded in the principles of Benefit-Cost Analysis (BCA), the standard methodology for project prioritization and regulatory oversight. BCA metrics include BCR. Agencies at all levels of government have worked to develop standardized BCA

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[13] National Energy Screening Project (NESP), National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources, August 2020.

[14] R. Broderick, J. Robert, K. Jones, J. Kallay, S. Letedre, T. Woolf, B. Havumaki, S. Kwok and A. Hopkins, "Application of a Standard Approach to Benefit-Cost Analysis for Grid Resilience Investments," Sandia National Laboratories, 2021.

methodologies. Most draw on the guidance in OMB Circular A-94, which states that projects must fulfill the policy objectives outlined in statutes, administrative rulings, or agency initiatives. "The rationale for the Government projects being examined should be clearly stated in the analysis. Subject to statutory constraints, projects may be justified on efficiency grounds where they address market failures, such as market power, public goods, externalities, and asymmetric information. Behavioral biases might also be considered to be a source of market failure. Projects may also be justified where they improve the efficiency of the Government's internal operations, such as cost-saving investments. More broadly, they may be justified where they have desirable distributional effects or promote important social values." The OMB Circular explains that to enable credible comparisons among projects, both a well-defined baseline and multiple project alternatives must be developed and compared. Only the most beneficial options will be approved, with the resulting calculation of Net Benefits providing the primary criterion for approval.[15]

While Circular A-94 emphasizes the Net Benefit metric to prioritize projects based on absolute benefit, the BCR is often the preferred metric for prioritizing projects under constrained budgets, where cost-efficiency, as opposed to absolute benefit, is the predominating decision-making criterion.[16] The U.S. Department of Transportation builds upon Circular A-94 by adding the Benefit-Cost Ratio as a decision-making metric and requires that both baselines and alternatives be forecast incrementally into the future. Additional discussion on the rationale for using BCR versus Net Benefit metrics in decision-making where budget limits apply is provided in Section 3.4 below.

As energy efficiency, renewable energy, and distributed energy resources (DER) have advanced, so too have the tools used to evaluate their cost-efficiency. The National Energy Screening Project developed the National Standard Practice Manual (NSPM) for Cost-Benefit Analysis of DERs, which lays out a set of principles and jurisdiction-specific methodologies for evaluating these emerging technologies.[17] These BCA principles have been widely adopted to analyze the value of specific utility investments, from major transmission projects[18] to energy efficiency programs.[19]

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15 Office of Management and Budget, "Circular No. A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," November 2023.

16 U.S. Department of Transportation, "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," May 2025, at 35.

17 National Energy Screening Project (NESP), National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources, August 2020.

18 J. W. Chang, J. P. Pfeifenberger and J. M. Hargerty, "The Benefits of Transmission: Identifying and Analyzing the Value of Investments," The Brattle Group, Washington, D.C., 2013.

19 B. Brendon, "Everyone Benefits: Recommendations for Utility System Benefits of Energy Efficiency," 2015.

Across the U.S., many states are working to standardize their BCA frameworks to better reflect the evolving energy landscape. Minnesota, initially reliant on California's Standard Practice Manual, found it insufficient for DER evaluation and formally adopted the NSPM.[20] Michigan, Colorado, and Maryland are developing unified BCA frameworks and have either adopted or are actively considering the NSPM.[21, 22, 23] Meanwhile, New Jersey and New York have created their own frameworks in cooperation with their Investor-Owned Utilities (IOU).[24, 25]

Although these BCA methodologies align on many core principles, they diverge in one key aspect: the treatment of avoided costs (i.e., cost savings). This distinction is critical: categorizing avoided costs as a benefit (in the numerator) rather than subtracting them from costs (in the denominator) can significantly alter a project's BCR, affecting project prioritization and decision-making, especially under constrained budgets. The utility tests widely used in the past did consider avoided (supply) costs as benefits, but only to the extent they apply directly to ratepayer bills.[26] Similarly, agencies like the U.S. DOT instruct that any reduced O&M costs relative to the baseline be considered a benefit when new projects replace or upgrade existing infrastructure.[27]

Recent frameworks take this further, treating avoided costs as benefits regardless of which party benefits and whether a project replaces older infrastructure.[28] For example, avoided transmission losses can reduce the need to procure power at high Locational Marginal Prices, thereby reducing costs for both utilities and ratepayers.[29] The New Jersey Board of Public

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[20] Minnesota Department of Commerce, Energy Division, "2024-2026 CIP Cost-Effectiveness Methodologies for Electric and Gas Investor-Owned Utilities," 2023.

[21] Michigan Public Service Commission, "Benefit-Cost Analysis Tool Collaborative," April 2025.

[22] Colorado Public Utilites Commission , "Proceeding No. 19R-0608E; In The Matter Of The Proposed Amendments To Rules Regulating Electric Utilities, 4 Code Of Colorado Regulations 723-3, Relating To Community Solar Gardens," June 2020.

[23] E4TheFuture Consultant Team, "Maryland Unified Benefit-Cost Analysis (UBCA) Framework for Distributed Energy Resources," May 2024.

[24] New Jersey Board of Public Utilities, Division of Clean Energy, "New Jersey Cost Test," 2023.

[25] NYSEG/RG&E, "Benefit Cost Analysis Handbook," no. Version 5, June 2025.

[26] California Public Utilities Commission, California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects, 2001.

[27] U.S. Department of Transportation, "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," May 2025.

[28] National Energy Screening Project (NESP), National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources, August 2020.

[29] NYSEG/RG&E, "Benefit Cost Analysis Handbook," no. Version 5, June 2025.

Utilities goes further, defining almost any avoided cost as a benefit.[30] Meanwhile, the Joint Utilities of New York consider any change in O&M costs a benefit to be included in the numerator of the BCR. They also explain how losses in system performance should be included in calculations of project benefits.[31]

These differing practices raise a fundamental question: what qualifies as a benefit rather than a cost, especially in the context of benefit-cost analysis? The remainder of this proposal explores this question in depth, examining how different policy choices in classifying costs and benefits can materially influence BCR outcomes. Staff analyzes the implications of these choices for investment prioritization, decision-making, regulatory consistency, and opportunity cost across mitigation strategies – all principles the Commission must consider in this SB 884 proceeding.

2.2 Evolution of the CPUC's Risk-Based Decision-Making Framework

On November 14, 2013, the Commission opened Rulemaking (R.) 13-11-006, an Order Instituting Rulemaking (OIR) to develop a risk-based decision-making framework to evaluate safety and reliability improvements and revise the Rate Case Plan (RCP) for Energy Utilities.[32] The purpose of this rulemaking was to incorporate a risk-based decision-making framework into the General Rate Case (GRC) processes, through which utilities request funding for safety-related activities.

Subsequently, in Decision (D.)14-12-025, the Commission formally modified the existing RCP to incorporate risk-based decision-making into the GRC process for the major investor-owned utilities in California. This decision also created two complementary processes:

- The Safety Model Assessment Proceeding (S-MAP), held every three years, assesses and standardizes utility risk models.
- The Risk Assessment and Mitigation Phase (RAMP), to be included in each utility's GRC to evaluate proposed risk mitigation plans.

The purpose of S-MAP was twofold: (1) to allow stakeholders to review and understand utility models for risk assessment and reduction, and (2) to establish Commission standards for those models. Each S-MAP was intended to inform a CPUC decision endorsing a particular model or variant for use in future RAMP filings.

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30 New Jersey Board of Public Utilities, Division of Clean Energy, "New Jersey Cost Test," 2023.

31 NYSEG/RG&E, "Benefit Cost Analysis Handbook," no. Version 5, June 2025.

32 California Public Utilities commission, Rulemaking 13-11-006 ; Order Instituting Rulemaking to Develop a Risk-Based Decision-Making Framework to Evaluate Safety and Reliability Improvements and Revise the General Rate Case Plan for Energy Utilities," November 2013.

The CPUC order in D.16-08-018 marked a key milestone by directing utilities to adopt a MAVF approach to quantify and prioritize risks based on such attributes as safety, reliability, and financial consequences. This approach was further formalized in D.18-12-014**,** which required MAVF-based risk scoring and a minimum 40 percent weight for the safety attribute, unless justified otherwise.

The MAVF approach enabled utilities to score risk reductions across several attributes, safety, reliability, and financial consequences, by assigning each a scaling range and weight to produce an overall risk score. The RSE metric, defined as the ratio of risk reduction to mitigation cost, uses these scores to rank projects by cost-efficiency and to prioritize mitigation investments. However, both MAVF and RSE were criticized for relying on utility-specific assumptions, a lack of standardization across utilities and projects, and an inability to determine whether benefits exceeded costs in absolute terms. Thus, in the RDF proceeding, the CPUC Safety Policy Division (SPD) Staff Proposal[33] and the 2022 Level 4 Ventures report[34] identified these issues and recommended transitioning to a cost-benefit approach with standardized economic valuation. This recommendation ultimately led to the rulemaking[35] which introduced the BCR as a replacement of MAVF and RSE assigning standardized dollar values to risk attributes such as safety, reliability, and financial consequences. Staff also proposed using federal guidance, such as the U.S. Department of Transportation's Value of a Statistical Life (VSL), and the Interruption Cost Estimator (ICE) Calculator developed by Lawrence Berkeley National Lab for electric reliability valuation.[36]

In D.22-12-027, the CPUC initiated this shift by adopting a standardized cost-benefit framework under the third S-MAP (R.20-07-013). Key changes include requiring BCR for each GRC and introducing SPD's tranche granularity approach[37] to improve consistency and comparability across projects. The decision also mandated monetized risk values for safety, reliability, and financial consequences. It directed utilities to implement the new framework starting with PG&E's 2024 RAMP and set the stage for further refinement in future phases.

In August 2025, the Commission adopted D.25-08-032, which finalized Phase 4 of the risk-based decision-making reform. This decision required utilities to model risk and

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33 CPUC Safety Policy Division, "Staff proposal on phase II Rulemaking 20-07-013," April 2022.

34 M. Henrion, "Comparing the MAVF and RSE with the proposed Cost-benefit framework," August 2022.

35 California Public Utilities Commission, "Rulemaking 20-07-013; Order Instituting Rulemaking to Further Develop a Risk-Based Decision-Making Framework for Electric and Gas Utilities.," April 2022.

36 Lawrence Berkeley National Laboratory, " The Interruption Cost Estimate (ICE) Calculator".

37 Tranche granularity approach refers to evaluating and reporting mitigation investments in smaller, discrete segments with relatively homogeneous risk profiles, enabling more practical and precise cost-efficiency assessments and stronger regulatory oversight.

consequence as probability distributions, calculate overall residual risk, and optimize mitigation portfolios under multiple budget scenarios using BCRs. It also standardized project definitions and data granularity through the Risk Reporting Unit (RRU), introduced accountability reporting via the Risk Mitigation Accountability Report (RMAR), and adopted a data template to improve transparency. These requirements take effect beginning with SCE's 2026 RAMP and Sempra's 2028 GRC.

In parallel, as part of implementing Senate Bill 884, Resolution SPD-37 required large electrical corporations to jointly propose a consistent and transparent methodology for calculating BCR across projects and utilities in the Application addressed by this Staff proposal.

3 Conceptual Foundation of BCRs

3.1 Defining Costs, Benefits and Disbenefits

Generally speaking, any mitigation program or project attempts to address some unsatisfactory condition.[38] In doing so, it generates outcomes (i.e., benefits) and costs. Costs are resources that could have been used for other purposes and thus represent opportunity costs.[39] These include not only financial expenditures, such as capital investments, but also foregone alternatives. Impact analysis frameworks are used to evaluate these trade-offs by examining the relationship between inputs (costs) and outcomes. Cost-Effectiveness Analysis (CEA) is a technique used to compare the costs of alternative ways to achieve a specific, predetermined objective. In this framework, benefits are not given a monetary value; instead, they are measured in natural or physical units, such as the number of injuries prevented or tons of emissions reduced. A project is considered cost-effective if it achieves a given level of benefit at the lowest possible cost or provides the maximum benefit for a fixed cost. This method is typically used when it is difficult or impractical to assign a dollar value to benefits, or when a policy mandate requires achieving a specific outcome regardless of economic efficiency. Benefit-Cost Analysis (BCA) is a more comprehensive economic assessment where all major benefits and costs are converted into a common monetary unit, typically dollars. This allows for the calculation of Net Present Value (NPV) and BCR, discussed in Section "NPV vs BCR "_ of this Staff proposal. Unlike cost-effectiveness, BCA allows decision-makers to determine if the total benefits to society outweigh the costs (a Benefit-Cost Ratio > 1.0). For instance,

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[38] L. B. Mohr, Impact Analysis for Program Evaluation, 2nd. Edition, 1995.

[39] H. M. Levin and P. J. McEwan, Cost-Effectiveness Analysis, 2nd Edition, 2001

while an RSE score can rank mitigations by relative cost-effectiveness, only a BCA can confirm if a risk mitigation's monetized benefits exceed its investment price. Furthermore, a BCA framework allows standardized comparison of risk reduction and cost efficiency across projects and utilities by using universal monetary trade-off values.[40, 41]

Thus, in BCA, benefits are conceived as monetized project outcomes. Some of those outcomes may be unsatisfactory, in which case they can be thought of as disbenefits, but remain analytically distinct from costs. For example, something in a project can lead to environmental degradation which negatively impacts surrounding communities. Disbenefits cannot be ignored since they are part of a project's outcomes. Nor are disbenefits costs since they are outcomes.[42] While some components of cost, such as new O&M expenses, are sometimes subtracted against avoided costs or even included on the benefit side for calculation simplicity and consistency, there remains a conceptual distinction between benefits (including disbenefits) and core costs, such as capital investments, which are placed in the denominator of the BCR.[43, 44]

This distinction is important: costs represent the resources expended to implement a project, whereas benefits represent the outcomes, positive or negative, generated by that project.[45, 46] Maintaining this distinction supports analytical transparency and ensures consistency in regulatory review and investment prioritization.

3.2 The BCR as a Decision-making Metric

BCR is one of the most widely used and intuitively understood measures of economic efficiency for public infrastructure and utility-sector decision-making. Conceptually, the BCR expresses the ratio of the present value of total benefits to the present value of total costs for a

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[40] Office of Management and Budget, "Circular No. A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," November 2023.

[41] H. M. Levin and P. J. McEwan, Cost-Effectiveness Analysis, 2nd Edition, 2001.

[42] S. Kant Vajpayee and M.D. Sarder, "Fundamentals of Economics for Applied Engineering, Second Edition", CRC Press, Taylor &Francis Group, 2022.

[43] U.S. Department of Transportation, "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," May 2025.

[44] A. Boardman, D. Greenberg, A. Vining and D. Weimer, "Cost-Benefit Analysis: Concepts and Practice," 2018.

[45] H. M. Levin and P. J. McEwan, Cost-Effectiveness Analysis, 2nd Edition, 2001.

[46] D. Sailman, E. Flanigan, K. Jennotte, C. Hedden and D. Morailos, "Operations Benefit/Cost Analysis Desk Reference," US Department of Transportation, 2012.

given project or mitigation. When the ratio exceeds one, benefits outweigh costs, indicating that the investment yields a positive net value to society or ratepayers.[47, 48, 49] Mathematically, this can be expressed as:

$$BCR = \frac{PV(Benefits)}{PV(Costs)} \quad (1)$$

Equation (1) expresses the core logic of cost-efficiency analysis, where projects are judged based on the ratio of their monetized benefits to their associated costs, both discounted to present value. The simplicity of the BCR makes it a powerful decision-making metric, providing a transparent, consistent, and traceable measure that supports regulatory oversight and enables utilities to consistently prioritize and select projects across diverse types and sizes. Within the CPUC's RDF, the BCR facilitates consistent evaluation of mitigation effectiveness both across and within utilities, helping to ensure that investments deliver the greatest achievable benefits within fixed funding levels and practical constraints.

The commission switched from RSE and MAVF because the BCR is conceptually simple and easy to interpret. However, its practical application requires careful attention to methodological consistency, robustness, and comparability to ensure that results remain just, reasonable, and traceable across different projects, risk events, and utilities. In practice, variations in underlying assumptions such as baseline definitions, discounting, and the treatment of costs and benefits, can significantly influence BCR calculation outcomes. This proposal discusses several of these methodological considerations in Section Methodological and Policy Implications.

3.3 Mandated or Discretionary programs

The interpretation and application of the BCR may also differ depending on whether a mitigation is mandated or discretionary.[50, 51] For mandated measures, such as compliance-driven safety upgrades or statutory wildfire mitigation requirements, the BCR should not serve as a pass/fail test but rather as a diagnostic tool to inform future regulatory refinement and program design. In such cases, BCR results can guide the CPUC in adjusting standards, prioritizing cost-efficient compliance pathways, or modifying requirements to ensure that

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[47] L. B. Mohr, Impact Analysis for Program Evaluation, 2nd. Edition, 1995.

[48] A. Boardman, D. Greenberg, A. Vining and D. Weimer, "Cost-Benefit Analysis: Concepts and Practice," 2018.

[49] H. M. Levin and P. J. McEwan, Cost-Effectiveness Analysis, 2nd Edition, 2001.

[50] Pacific Gas & Electric Company, "PG&E 2022 Wildfire Mitigation Plan – Final Revision Notice Responses," July 2022.

[51] Public Advocates Office, "Public Advocates Office Reply Brief-Application 21-06-021," December 2022.

public safety objectives are achieved efficiently. In contrast, for discretionary investments such as SB 884 applications, where utilities have latitude in project selection, the BCR serves as a strategic screening and prioritization tool, ensuring that limited ratepayer funds are directed toward projects with the highest proportional benefit-to-cost.

By serving these distinct functions – diagnosis for mandates and prioritization for discretionary spending – the BCR provides a versatile regulatory tool. This versatility is particularly valuable in constrained budget environments, where, as discussed in the following section, the BCR offers distinct advantages over absolute metrics such as NPV.

3.4 NPV vs BCR

NPV represents the present value of total benefits minus the present value of total costs over the life cycle of a proposed alternative. A positive NPV indicates that a project delivers net benefits to society and is therefore considered economically justified. While NPV is one of the most widely accepted and conceptually straightforward metrics in cost-benefit analysis, it does not inherently support cost-efficient project prioritization and selection when funding is constrained. In such contexts, it may favor large-scale projects with high total net benefits but low proportional efficiency. By contrast, the BCR is particularly useful when decision-makers face budgetary limitations, as it enables prioritizing projects that yield the highest return (e.g., the highest risk reduction) per unit of cost.[52, 53, 54]

In other words, NPV emphasizes absolute value, making it the preferred criterion when the objective is to maximize total benefits. BCR, on the other hand, emphasizes relative cost-efficiency, making it more suitable for portfolio optimization under limited funding scenarios, such as in utility investment planning, where affordability and ratepayer impact are central considerations.

3.5 BCR-Based versus Risk-Based Optimization

While the comparisons between NPV and BCR highlight the trade-offs between absolute value and relative efficiency, a distinct but equally critical tension exists between economic efficiency

[52] Office of Management and Budget, "Circular No. A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," November 2023.

[53] A. Boardman, D. Greenberg, A. Vining and D. Weimer, "Cost-Benefit Analysis: Concepts and Practice," 2018.

[54] B. Sieren-Smith, A. Jain, A. Eshraghi, S. Hurd, J. Ende, J. Huneycutt, A. Ngo, M. LeBel, C. Linvill and D. Roland-Holst, "Utility Costs and Affordability of The Grid of The Future an Evaluation of Electric Costs, Rates and Equity Issues Pursuant To P.U. Code Section 913.1," California Public Utilities Commission, 2021.

and pure risk reduction.[55, 56] Regulators and utilities typically diverge between two primary optimization strategies when developing mitigation portfolios:

- Risk Reduction–Based optimization: This approach ranks projects from highest to lowest absolute risk. It prioritizes the highest-risk projects first, treating the budget primarily as a ceiling, and selects projects further down the ranking until the available budget is exhausted.
- BCR-Based optimization: This approach ranks projects based on their BCR. It prioritizes the most cost-efficient projects first, those delivering the highest monetized benefits per dollar of cost, and continues selecting projects until the available budget is exhausted.

These differing objectives lead to materially different portfolio outcomes. Risk reduction–based planning tends to favor capital-intensive, large-scale infrastructure projects, which may achieve substantial risk reduction in a specific location but often at a high unit cost and lower relative cost-efficiency. While effective, these projects often exhibit diminishing marginal returns. By contrast, BCR-Based optimization typically favors a portfolio of targeted, highly efficient mitigations that may be smaller in individual scope but offer superior cost-efficiency.

Crucially, in a constrained budget environment, a reality for all ratepayer-funded systems, BCR-Based optimization mathematically yields the superior aggregate risk reduction.[57, 58] By prioritizing high-efficiency projects first, which vary in size, cost, and absolute risk impact, the utility effectively addresses the maximum possible risk for every dollar available. Conversely, prioritizing based strictly on absolute risk reduction tends to favor larger, capital-intensive projects. Risk Reduction–Based optimization effectively crowds out other cost-efficient opportunities because it prioritizes projects based on absolute risk reduction rather than risk reduction per dollar. As a result, large, capital-intensive projects that reduce more risk consume a disproportionate share of a fixed budget, leaving insufficient funding for smaller projects that may address lower risk individually but, when combined, would deliver greater aggregate risk reduction for the same budget. Thus, the Risk Reduction–Based optimized portfolio spends less overall to achieve the same level of risk reduction for the ratepayer as the BCR-optimized portfolio, given the same budget.

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[55] M. Henrion, "Comparing the MAVF and RSE with the proposed Cost-benefit framework," August 2022.

[56] Office of Management and Budget, "Circular No. A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," November 2023.

[57] A. Boardman, D. Greenberg, A. Vining and D. Weimer, "Cost-Benefit Analysis: Concepts and Practice," 2018.

[58] B. Sieren-Smith, A. Jain, A. Eshraghi, S. Hurd, J. Ende, J. Huneycutt, A. Ngo, M. LeBel, C. Linvill and D. Roland-Holst, "Utility Costs and Affordability of The Grid of The Future an Evaluation of Electric Costs, Rates and Equity Issues Pursuant To P.U. Code Section 913.1," California Public Utilities Commission, 2021.

4 Methodological and Policy Implications

4.1 The Significance of the Baseline in BCR Analysis

A fundamental methodological consideration in BCR analysis is the definition of the baseline scenario, which establishes the reference condition against which all benefits and costs are measured.[59] The baseline provides the analytical foundation for evaluating (incremental) benefits and costs associated with proposed mitigation measures and ensures that evaluations are conducted within a consistent, transparent, and traceable framework.[60]

Within the CPUC's Risk-Based Decision-Making Framework,[61] a consistent baseline is essential to enable comparability across utilities, projects, and filings. Inaccurate or inconsistent baselines can materially distort BCR outcomes, either by overstating benefits (e.g., assuming no existing infrastructure) or understating them (e.g., assuming unrealistically high baseline performance). The following three baseline configurations are presented to illustrate how the choice of baseline can significantly affect BCR calculations and their policy interpretation.

4.2 Baseline Scenario 1: Unmitigated Baseline (No-Infrastructure Baseline)

This baseline scenario assumes a complete absence of existing infrastructure or mitigation, for example, a bare system without vegetation management (VM), inspections or hardening. It captures the full theoretical benefit of a proposed mitigation by measuring all benefits and costs relative to a fully unprotected state.[62] While useful for establishing the absolute upper bound of risk in long-term planning exercises,[63] Baseline Scenario 1 is generally unsuitable for regulatory cost-recovery proceedings, where utilities already operate complex infrastructures with existing mitigation measures in place. Evaluating a new project against this baseline would artificially inflate the BCR by claiming credit for risk reductions that are already achieved by

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59 L. B. Mohr, Impact Analysis for Program Evaluation, 2nd. Edition, 1995.

60 U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, May 2025.

61 D.25-08-032: Phase 4 Decision RDF, 2025

62 M. Henrion, "Comparing the MAVF and RSE with the proposed Cost-benefit framework," August 2022.

63 J. W. Chang, J. P. Pfeifenberger and J. M. Hargerty, "The Benefits of Transmission: Identifying and Analyzing the Value of Investments," The Brattle Group, Washington, D.C., 2013.

existing, funded programs (e.g., standard VM). This violates the incremental principle that ratepayers should not pay twice for the same unit of risk reduction.[64]

4.3 Baseline Scenario 2: No-Build Baseline (Statues Quo Baseline)

The No-Build Baseline establishes the current risk profile of the system, incorporating all infrastructure and risk controls that are already funded, approved, or implemented (e.g., existing VM and inspection cycles). This baseline serves as the calibrated reference point for determining the marginal (i.e., incremental) value of any single new investment.

In this baseline scenario, the BCR quantifies the incremental benefit of a specific new mitigation given the presence of the existing controls (i.e., No-Build Baseline). By accounting for the benefits of the existing programs into the baseline, Scenario 2 ensures that the new mitigation is only credited for the additional risk reduction it provides beyond what is already achieved. This prevents double-counting and aligns with the standard regulatory practice of measuring benefits as reductions in expected loss relative to current status quo conditions.

$$BCR = \frac{PV\,(B_{with\ mitigation} - B_{No\text{-}Build\ Baseline})}{PV(C_{with\ mitigation} - C_{No\text{-}Build\ Baseline})} \qquad (2)$$

From a policy standpoint, this approach establishes a uniform reference point across utilities, promoting consistency in filings. It represents the methodology endorsed by federal guidelines and standardized electric utility benefit-cost frameworks, which define the credible baseline as the system's projected performance including all standard operating procedures and previously authorized investments While Baseline Scenario 2 requires detailed utility-specific data, such as asset condition and failure rates, it fulfills the Commission's holding in D.25-08-032 that mitigation benefits must be measured against the continuation of current system conditions.[65, 66, 67]

A critical application of Baseline Scenario 2 arises when evaluating interacting incremental projects where a new project (Mitigation B) is evaluated in the context of an existing or already-approved project (Mitigation A). The analysis must reflect the interdependence of their

[64] A. Boardman, D. Greenberg, A. Vining and D. Weimer, "Cost-Benefit Analysis: Concepts and Practice," 2018.
[65] U.S. Department of Transportation, "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," May 2025.
[66] A. Boardman, D. Greenberg, A. Vining and D. Weimer, "Cost-Benefit Analysis: Concepts and Practice," 2018.
[67] NYSEG/RG&E, " Benefit Cost Analysis Handbook," no. Version 5, June 2025.

performance (benefits). The incremental benefit for Mitigation B should be calculated as the difference between the combined benefit of both projects and the benefit already provided by the baseline project:

$$\textit{Incremental Benefit (B)} = \textit{Benefit (A+B)} - \textit{Benefit (A)} \qquad (3)$$

This formulation explicitly captures nonlinear interaction effects, acknowledging that the marginal contribution of Mitigation B may be synergistic (greater than its standalone value) or antagonistic (less than its standalone value). Crucially, the denominator of the BCR includes only the incremental cost of Mitigation B, as the capital cost of Mitigation A is effectively sunk within the baseline. Furthermore, in some cases, the new project may also eliminate part of ongoing costs associated with the existing baseline project. These avoided expenditures are treated as O&M Savings. Their placement within the BCR equation, whether as a reduction in the denominator (The Cost-Basis Formulation), or an addition to the numerator (The Benefit-Basis Formulation and The Disaggregated Formulation), depends on the specific calculation method selected, as defined and analyzed in the following section.

4.4 Baseline Scenario 3: Portfolio-Level Incremental Baseline

Baseline Scenario 3 extends Baseline Scenario 2 from individual projects to a portfolio of new mitigations, none of which exist in the No-Build Baseline. Under this scenario, the BCR quantifies the combined incremental impact of multiple proposed mitigations (e.g., a portfolio combining covered conductor installation and REFCL[68] technology) relative to the status quo. This scenario enables consistency between project-level analyses and program-level reporting and filings, such as in RAMP filings. However, Baseline Scenario 3 requires more sophisticated modeling to capture potential interactions among mitigations. Failing to explicitly model redundancies or overlaps risks materially misestimating benefits.

From a policy standpoint, this baseline scenario offers utilities flexibility to prioritize portfolios that achieve the greatest overall cost-efficiency. Simultaneously, it allows regulators to assess aggregated BCRs to ensure transparency, consistency, and equitable ratepayer outcomes. Thus, Baseline Scenario 3 supports integrated (risk reduction) planning, enabling the Commission to evaluate mitigation portfolios in aggregate while preserving methodological alignment with the incremental framework established under Baseline Scenario 2.

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[68] Rapid Earth Fault Current Limiter.

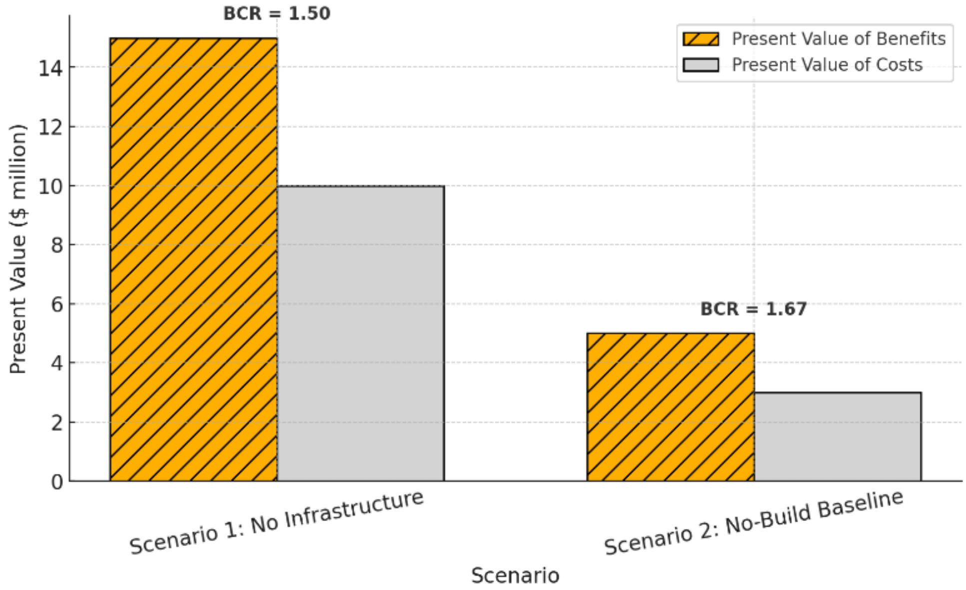

Figure 1: Comparing the BCR calculations for Baseline Scenario 1 and Baseline Scenario 2[69]

Figure 1 compares Baseline Scenario 1 (No-infrastructure Baseline) where benefits and costs are measured relative to an unmitigated system, (e.g., no VM or inspection exists) to Baseline Scenario 2 (No-Build Baseline) where the baseline includes mandated measures such as existing VM and inspection.

While Baseline Scenario 1 captures the asset's total theoretical value, Baseline Scenario 2 typically yields a higher BCR. This occurs because the No-Build Baseline explicitly accounts for the inefficiency of legacy mandates by displacing some of these lower-efficiency operational costs with higher-efficiency technological solutions (like covered conductors), thereby increasing the marginal risk reduction per dollar spent.

A critical observation is that, in some instances, methodological asymmetry may be applied, mixing baseline assumptions in ways that distort outcomes. For example, an analysis might utilize total costs (Baseline Scenario 1 logic) while counting only incremental benefits (Baseline Scenario 2 logic), or conversely, claim total benefits while accounting for only incremental costs. Such inconsistent treatment systematically distorts the BCR, often biasing results in favor of specific project types; notably, the former asymmetry tends to favor capital-intensive mitigations. This issue has been identified and discussed in detail by CPUC SPD staff in the recent Sempra RAMP Report[70], where such analytical inconsistencies were shown to

[69] Unless otherwise noted, all numerical values and figures presented in this paper are synthesized for illustrative purposes based on reasonable approximations of real-world data.

[70] CPUC Safety Policy Division, "Applications 25-05-10; Safety Policy Division Evaluation Report on Sempra's 2025 RAMP," October 2025.

significantly alter comparative cost-efficiency outcomes and potentially misguide capital allocation.

4.5 O&M Formulations in BCR calculations

In a typical BCR framework, risk reduction benefits[71] are placed in the numerator, while capital costs are placed in the denominator. While the capital investment cost is straightforward and constitutes the core of the denominator, incorporating O&M Costs and savings introduces additional complexity, especially across different baseline scenarios. There are two main O&M-related elements that may be included in a BCR calculation:

- (Incremental) O&M Costs: Under Baseline Scenario 2 (No-Build Baseline), Incremental O&M Costs are defined as the additional O&M expenditures required by the project or mitigation relative to the No-Build Baseline. For example, installing covered conductor may require specialized maintenance or more frequent inspections. In contrast, Baseline Scenario 1 includes all post-mitigation O&M Costs, both new and previously existing, since it assumes no mitigation is in place. Consequently, O&M Costs appear significantly larger under Baseline Scenario 1 because the analysis captures the entire operational burden rather than just the marginal increase.[72, 73]

- O&M Savings: These represent the avoided O&M expenditures associated with the No-Build Baseline that are eliminated by the project or mitigation. For instance, undergrounding or covered conductors may reduce or eliminate the need for VM. O&M Savings are recognized only under Baseline Scenario 2, where the Baseline accounts for existing mitigations that can be displaced. In Baseline Scenario 1, O&M Savings are zero, as there is no existing mitigation to improve upon. This is a key limitation that prevents Scenario 1 from capturing operational efficiencies achieved by replacing already-funded strategies.[74]

[71] A key policy consideration is the definition of which benefits, and risk reductions qualify for inclusion in the BCR calculation. In many cases, policymakers or regulatory authorities explicitly define the categories of benefits and costs that may be included in the cost risk analyses within a given proceeding, and those definitions must be applied consistently within that framework.

[72] Office of Management and Budget, "Circular No. A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," November 2023.

[73] A. Boardman, D. Greenberg, A. Vining and D. Weimer, "Cost-Benefit Analysis: Concepts and Practice," 2018.

[74] U.S. Department of Transportation, "Benefit-Cost Analysis Guidance for Discretionary Grant Programs," May 2025.

There are several distinct formulations for incorporating O&M Costs and Savings into the BCR. While they share the same underlying economic logic, their structural differences can lead to instability and inconsistency issues in regulatory settings.

4.6 The Cost-Basis Formulation: Net O&M in Denominator

This approach combines O&M Costs and O&M Savings into a Net O&M value (O&M Savings minus O&M Costs) and subtracts that Net O&M value from capital costs in the denominator.[75]

This formulation bundles all resource costs (capital and operational) into a single denominator, making it structurally intuitive. However, if O&M Savings are substantial enough to exceed or even equal the sum of capital and new O&M Costs, the denominator becomes negative or zero, resulting in an analytically or mathematically invalid BCR.

The Cost-Basis Formulation BCR is calculated as:

$$BCR = \frac{\textit{Risk Reduction Benefits}}{\textit{Capital Costs} - (\textit{O\&M Savings-O\&M Costs})} \qquad (4)$$

4.7 The Benefit-Basis Formulation: Net O&M in Numerator

This formulation adds Net O&M value to the benefit side of the BCR.[76] If O&M Savings exceed Costs, the result is a net positive addition to the numerator. While the Benefit-Basis Formulation addresses the Cost-Basis Formulation's inconsistencies, specifically regarding negative and invalid BCR values, it effectively applies only to capital-intensive projects. Critically, the Benefit-Basis Formulation fails to generate consistent results for projects with no capital costs and only O&M Costs, as the lack of capital expenditure results in a zero denominator.

The Benefit-Basis Formulation BCR is calculated as:

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[75] Office of Management and Budget, "Circular No. A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," November 2023.

[76] See Footnote 75.

$$BCR = \frac{Risk\ Reduction\ Benefits + (O\&M\ Savings - O\&M\ Costs)}{Capital\ Costs} \quad (5)$$

4.8 The Disaggregated Formulation

This formulation separates the O&M components entirely: O&M Costs are added to the denominator (as a cost), and O&M Savings are added to the numerator (as a benefit).[77] Critically, this formulation addresses the structural inconsistencies of previous approaches by avoiding negative BCR values resulting from negative denominators and enabling the evaluation of projects with negligible or zero capital expenditure.

The Disaggregated BCR is calculated as:

$$BCR = \frac{Risk\ Reduction\ Benefits + O\&M\ Savings}{Capital\ Costs + O\&M\ Costs} \quad (6)$$

It is worth noting that the Cost-Basis Formulation, the Benefit-Basis Formulation, and the Disaggregated Formulation are mathematically equivalent in determining whether a project's BCR exceeds 1 or falls below 1 as long as the outcomes of these formulations are positive and mathematically valid. Although they differ in framing, they yield the same directional decision.

For example, let

- B = benefits
- C = Capital costs
- O = Net O&M (Note: O is positive if there are net savings, and negative if there are net increases in O&M Costs.)

Assume a project is cost-efficient under the Cost-Basis Formulation:

$$\text{BCR}_{\text{Cost-Basis}} = \frac{B}{C - O} > 1$$

$$\Rightarrow B > C - O \Rightarrow B + O > C \Rightarrow \frac{B + O}{C} > 1$$

Thus, $\text{BCR}_{\text{Cost-Basis}} > 1 \iff \text{BCR}_{\text{Benefit-Basis}} > 1$, and the same applies for BCR < 1 and $\text{BCR}_{Disaggregated\ Formulation}$.

77 A. Boardman, D. Greenberg, A. Vining, and D.Weimer, Cost-Benefit Analysis: Concepts and Practice, 2018.

Conclusion: While the two formulations differ in framing (cost-focused vs. benefit-focused), they yield identical decisions on whether a project is cost-efficient as long as the outcomes of these formulations are positive and mathematically valid.

While the Disaggregated Formulation resolves the mathematical instabilities of the previous options, it imposes specific data requirements. **To implement this formulation effectively, utilities must explicitly report the O&M expenses for the No-Build Baseline, the avoided O&M costs (O&M Savings) resulting from displacing existing activities, and the new incremental O&M Costs introduced by the mitigation itself.**

Under Baseline Scenario 1 (No-Infrastructure), there are no O&M Savings since nothing exists to be avoided. Consequently, the Benefit-Basis Formulation and the Disaggregated Formulation yield identical formulations under this baseline scenario.

Ultimately, while all three formulations are technically valid under specific conditions, the selection of a method must be driven by consistency and application stability. As demonstrated in the case study below, applying these formulations to high-cost-savings projects reveals that structural choices can determine whether a project appears cost-efficient or mathematically undefined.

5 Application Case: Wildfire Risk and Undergrounding

5.1 Case Study Design

5.2 Mitigation Measures and Objective

To evaluate how different BCR formulations affect project prioritization, we apply three hypothetical methods across a set of illustrative wildfire mitigation examples. This case study focuses on two common utility mitigation strategies for wildfire risk reduction:

1. Undergrounding (UG): The placement of power lines beneath the ground,
2. Covered Conductor (CC): The use of insulated wires installed overhead.

The objective is to compare the cost-efficiency of these two different mitigation types under varied operational and financial assumptions to underscore the sensitivity of BCR outcomes to methodological choices. The six hypothetical examples presented in this case study illustrate how different BCR formulations respond to varying capital costs, O&M structures, and risk-reduction effectiveness profiles.

To maintain clarity in comparing the methodological approach, the examples focus only on existing baseline O&M and O&M Savings derived from displaced baseline activities, and neglect new post-mitigation O&M Costs. This simplification isolates the effect of methodological structure on BCR outcomes and avoids confounding factors unrelated to the comparison of formulas. These examples are illustrative and not intended to represent actual utility cost structures or real-world UG/CC performance.

5.3 Variables

The analysis uses six hypothetical examples (Example 1 through Example 6), which are combinations of three key variables that materially affect the calculated BCR:

1. Risk Reduction (RR): Examples vary the risk reduction effectiveness of CC relative to UG, testing two major assumptions:
    - CC is 80 percent as effective as UG (e.g., Examples 1–3).
    - CC is 40 percent as effective as UG (e.g., Example 4-6). This conservative assumption is derived from lower-bound performance estimates discussed in regulatory workshops used solely for testing sensitivity.[78]
2. Capital Costs: UG is assumed to cost twice as much as CC in all examples. For illustrative purposes, we assume UG has twice the capital cost of CC, a 2:1 cost ratio. This assumption is conservative: reported values from California utilities suggest UG can be 2.5x to 5x more expensive than CC, depending on terrain, permitting complexity, and location-specific engineering challenges.[79, 80] Using a 2x multiplier simplifies the comparison while preserving UG's relative cost disadvantage without overstating it, enabling clearer comparisons across methods.
3. O&M Cost Structure: Examples test both Normal O&M Conditions where No-Build Baseline O&M Costs (i.e., original O&M Costs prior to mitigation implementation) are low relative to capital cost, e.g., Examples 1 & 6 and Elevated O&M Conditions where No-Build Baseline O&M Costs are high, e.g., Examples 2–5.

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78 Southern California Edison Company, "2023-2025 Wildfire Mitigation Plan," March 2023.

79 Pacific Gas and Electric Company, "PG&E 2022 Wildfire Mitigation Plan," July 2022.

80 Southern California Edison, "Application 23-05-010; General Rate Case," May 2023.

5.4 Limitations

This case study is designed to illustrate how different BCR formulations can change BCR outputs which serve as one of the central metrics informing regulatory decision-makers as they evaluate prioritization and allocate limited ratepayer funding.

. Several limitations should be noted:

- *Illustrative Purpose Only:*
  The cost and benefit values are simplified to demonstrate conceptual trends, not to represent real-world data.
- *Omission of O&M Costs:*
  For simplicity, incremental O&M Costs introduced by mitigations (e.g., specialized inspection needs) are omitted. While relevant in practice, their inclusion would have added complexity without changing the core analytical insight. Future work could incorporate these factors more fully.
- *Methodological Scope:*
  This analysis focuses on three specific combinations of the formulations and Baseline Scenarios 1 and 2 discussed in Section IV. Assuming Incremental O&M Costs are zero, The Disaggregated Formulation and the Benefit-Basis Formulation yield identical results.
- *Mixed Baseline Assumptions:*
  Method2 applies Baseline Scenario 1 logic to CC's O&M values and Baseline Scenario 2 logic to UG and CC's benefits intentionally as a sensitivity test. This asymmetric treatment reflects how inconsistent baseline assumptions can lead to bias in real-world regulatory filings.

5.5 Methodological Setups

The comparative analysis tests the cost-efficiency of UG and CC under three distinct BCR calculation methods (Method1, Method2, and Method3). These methods differ primarily in their choice of baseline and their placement of O&M Costs and savings within the BCR equation. The three methods are defined in Table 1.

Table 1: Methodological Setups

Method	Description
Method1	Baseline Scenario 2 with the Cost-Basis Formulation: capital costs and Net O&M (Savings minus Costs) in the denominator. $$BCR = \frac{\text{Risk Reduction Benefit}}{\text{Capital Costs - O\&M Savings}}$$
Method2	Inconsistent Baseline: Uses Baseline Scenario 2 with the Cost-Basis Formulation for UG but shifts to the Baseline Scenario 1 for CC, penalizing CC by excluding O&M Savings and only adding No-Build Baseline O&M Costs which are the original O&M Costs prior to CC implementation. $$\mathrm{BCR}_{\mathrm{UG}} = \frac{\text{Risk Reduction Benefit}}{\text{Capital Costs - O\&M Savings}}$$ $$\mathrm{BCR}_{\mathrm{CC}} = \frac{\text{Risk Reduction Benefit}}{\text{Capital Costs + No-Build Baseline O\&M costs}}$$
Method3	Baseline Scenario 2 with the Disaggregated Formulation (or the Benefit-Basis Formulation since O&M Costs=0 and Net O&M = O&M Savings. It combines benefits and Net O&M in the numerator. This avoids situations where the denominator becomes zero or negative. $$\mathrm{BCR} = \frac{\text{Risk Reduction Benefit + O\&M Savings}}{\text{Capital Costs}}$$

5.6 Analysis of Results

This analysis examines the results from the six examples (presented in Table 2) to demonstrate the sensitivity of BCR outcomes to O&M structures and Baseline Scenario choices. Figure 2 shows the resulting BCR values for each example.

Table 2 : Comparative BCR across three methods and across six illustrative examples (in $ millions)

	CC's RR is only 80% of UG's						CC's RR is 40% of UG's					
			Elevated O&M Costs									
	Example1		**Example2**		**Example 3**		**Example 4**		**Example 5**		**Example6**	
	UG	**CC**	**UG**	**CC**	**UG**	**CC**	**UG**	**CC**	**UG**	**CC**	**UG**	**CC**
Risk Reduction	120	96	120	96	120	96	240	100	240	100	120	48
Capital Costs	100	50	100	50	100	50	100	50	100	50	100	50
O&M Savings	12	8	56	35	150	35	56	35	90	50	12	8
Original O&M Costs	15	15	70	70	200	200	70	70	100	100	15	15
Method 1	1.36	2.29	2.73	6.40	-2.40	6.40	5.45	6.67	24.00	NA	1.36	1.14
Method 2	1.17	1.48	1.05	0.80	0.80	0.38	2.11	0.83	2.18	0.67	1.17	0.74
Method 3	1.32	2.08	1.76	2.62	2.70	2.62	2.96	2.70	3.30	3.00	1.32	1.12

5.7 Normal O&M Conditions (Examples 1 & 6)

In Examples 1 and 6, where the No-Build Baseline O&M Costs including VM and inspections and O&M Savings are modest, all three calculation methods (Method1, Method2, Method3) yield similar trends. In these baseline scenarios, CC typically appears more cost-efficient than UG due to its significantly lower capital cost. However, this cost-efficiency advantage for CC disappears when/if its risk reduction effectiveness drops significantly (e.g., to 40% of UG, as seen in Example 6).

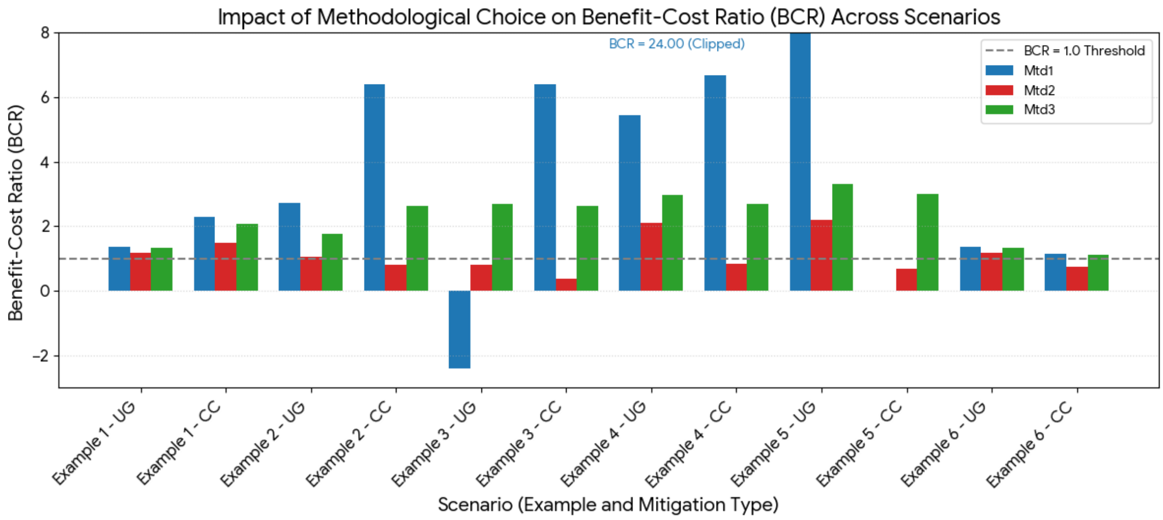

Figure 2 : Impact of Baseline Scenario and O&M structures on BCR outcomes

5.8 Elevated O&M Conditions (Examples 2–5)

Methodological differences become pronounced in Examples 2 through 5, which model elevated No-Build Baseline O&M Costs and possibly higher O&M Savings.

Method2 consistently favors UG. By applying Baseline Scenario 1 logic for CC's denominator (i.e., adding the No-Build Baseline O&M Costs to the denominator and ignoring O&M Savings) while using Baseline Scenario 2 logic for the numerator, this method inflates CC's cost base. This example highlights how inconsistent baseline definitions can affect analytical outcomes to favor capital-intensive projects.

Method1 demonstrates mathematical instability under high O&M Savings conditions. In Example 3, Net O&M for UG exceed capital costs, resulting in a negative denominator and a logically invalid negative BCR value (-2.40). A BCR greater than one indicates that a project's benefits exceed its cost with one being the breakeven point. BCRs less than one indicate projects whose costs are greater than any benefits delivered. A negative BCR cannot be interpreted. Furthermore, in Example 5, the BCR for CC becomes mathematically undefined ("NA") when Net O&M exactly offset capital costs, rendering the method unusable.

By contrast, Method3 maintains stability and avoids the mathematical inconsistencies of Method1 and the baseline biases of Method2, proving to be the most robust calculation method across all cost and risk conditions tested.

5.9 Implications for Project Evaluation and Regulatory Oversight

The case study confirms that stability and consistency are the paramount requirements for a robust BCR framework.

- Structural Stability: As shown in Example 3, The Cost-Basis Formulation is structurally incapable of handling high-savings projects (e.g., substantial vegetation management displacement). Specifically, netting capital costs against O&M Savings can produce negative or zero BCR denominators, resulting in invalid BCR results. Although the Benefit-Basis Formulation addresses some of these inconsistencies, it is not applicable to non-capital projects, because in this formulation, a zero capital costs yields a zero BCR denominator, and again resulting in an invalid BCR. A robust framework should therefore rely on a formulation, such as the Disaggregated

Formulation (like Method 3), that avoids negative and zero denominators, and consequently, mathematically undefined BCR results.

- Baseline Consistency: As shown in Method2, applying different baselines to different technologies introduces systematic bias. A reliable regulatory framework must enforce uniform baseline definitions across all mitigation types to ensure true comparability and accountability while maintaining decision-making consistency.

6 Conclusion

This paper has examined the regulatory transition from qualitative risk scoring to the Benefit-Cost Ratio as a central metric informing regulatory decision-makers as they evaluate prioritization and allocate limited ratepayer funding. Through a comparative analysis of calculation structures, we have demonstrated that the BCR is not merely a mathematical output but a function of specific policy choices including baseline definitions and the treatment of operational costs.

Accordingly, this paper establishes a set of guardrails—mainly for baseline scenario selection, O&M treatment, and optimization—that lead to a recommended BCR method to enable transparent, stable, and consistent regulatory decision-making. These guardrails are intended to minimize future inconsistencies and avoiding repetitive, resource-intensive cycles of justifications and paperwork.

We conclude that a robust and consistent BCR framework requires (a) selecting a well-defined, structurally stable formulation that doesn't fail under practical use cases and (b) enforcing methodological consistency across all projects, utilities, and mitigation types, with key methodological nuances explicitly defined rather than left to interpretation. We find that Method 3 answers those requirements and recommend the Commission adopt the Method 3 formulation.

Ultimately, the BCR serves as a bridge between the economic and regulatory dimensions of decision-making. It translates complex and multidimensional mitigation outcomes, ranging from avoided ignitions to improved reliability, and associated costs, spanning initial capital investments to ongoing O&M expenditures and savings, into a unified, transparent, and consistent measure of value. In doing so, it strengthens accountability, comparability, and consistency in how utilities plan, justify, and evaluate their mitigation projects, as well as how regulators exercise oversight and review of those investments.