Australasian Transport Research Forum 2025 Proceedings
18-21 November, Auckland, New Zealand
Publication website: https://australasiantransportresearchforum.org.au/

# Innovating affordably: A benefit–cost analysis framework for selecting BEV policies

V. Anilan[1], Akshay Vij[1], Jeff Connor[1], Helen Barrie[1] and Ali Ardeshiri[1]

[1] UniSA Business, University of South Australia, Adelaide, SA, Australia

Corresponding author: anilan.v@mymail.unisa.edu.au

This abridged paper is based on the article "Evaluating Battery Electric Vehicle Policies: A Benefit–Cost Analysis Framework," first published in Transportation (Springer Nature, 2025; https://doi.org/10.1007/s11116-025-10690-x). Reproduced in summary form with permission of the publisher.

## Abstract

This study evaluates six common policies promoting battery electric vehicle (BEV) adoption through a benefit–cost analysis (BCA) using Australia as a case study. A three-phase methodology—comprising a Delphi panel, a vehicle purchase decision model (VPDM), and risk-adjusted BCA—assesses each policy's impact on adoption, emissions reduction, and economic efficiency. Results show that fuel efficiency standard deliver the highest Benefit–Cost Ratio (BCR), although it does not produce the highest BEV adoption. Home charger rebates generate the greatest BEV uptake, offering strong financial returns and long-term energy security benefits. Public education and exposure campaigns emerge as cost-effective complements. In contrast, BEV purchase rebates, while accelerating uptake, yield a negative Net Present Value (NPV) and poor BCR due to free-rider effects. Operating-cost incentives show similarly weak returns. Public charging subsidies provide limited direct financial gains but remain critical for mitigating range anxiety and supporting regional connectivity. The findings underscore the importance of context-specific policy mixes tailored to infrastructure, behavioural, and market conditions. By disaggregating policy impacts and incorporating sensitivity, distributional, and risk analysis, this framework offers transferable insights for designing cost-effective, scalable BEV promotion strategies.

## 1 Introduction

Governments worldwide are investing heavily to accelerate the adoption of battery-electric vehicles (BEVs), yet questions persist over which policy instruments deliver the greatest value for money and how they should be sequenced. Fiscal incentives can boost early uptake but risk free-rider effects; infrastructure programs enhance confidence and visibility but have long payback horizons; and regulatory standards often prove efficient while shifting costs to manufacturers and consumers. Australia's evolving policy landscape provides a timely setting to evaluate these trade-offs systematically.

This study develops a context-sensitive benefit–cost analysis (BCA) framework to evaluate six widely used BEV-promotion policies over a 30-year horizon. The framework integrates (i) a Delphi expert-elicitation process to identify feasible, high-priority interventions, (ii) a behavioural Vehicle Purchase Decision Model (VPDM) to simulate adoption dynamics, and (iii) a risk-adjusted BCA that quantifies net present value (NPV), benefit–cost ratio (BCR), and distributional effects. The approach links behavioural realism with fiscal accountability to inform policy portfolios that are effective, efficient, and equitable under real-world conditions.

## 2 Methodology

The analysis proceeded in three stages. First, a Delphi study was undertaken with 16 experts from government, academia, and industry to identify policies most relevant to the Australian context and to refine implementation parameters. Consensus converged on six representative policy instruments: (1) BEV purchase rebates, (2) private charger rebates, (3) public charging infrastructure support, (4) operating cost incentives, (5) public exposure and awareness, and (6) fuel efficiency standard (FES).

Second, the behavioural modelling employed a Vehicle Purchase Decision Model (VPDM) integrating diffusion theory and discrete-choice utility logic following Higgins et al. (2012). It linked each policy to key consumer attributes—upfront price, annual running cost, driving range, charging time, public-charger density, and familiarity—and simulated the transition in market shares across BEV, Plug-in hybrid vehicle (PHEV), hybrid electric vehicle (HEV), and internal combustion engine vehicle (ICEV) segments. The model operated over a 30-year horizon, capturing feedback between technology uptake and cost decline.

Third, a risk-adjusted BCA quantified fiscal and societal outcomes using Monte Carlo simulation with 10,000 iterations. Assumptions included a 5% default social discount rate, A$76/t social cost of carbon, and parameter uncertainty for energy prices, technology costs, and uptake elasticities. Risk scores were derived across technical, financial, socio-political, and managerial domains to adjust NPVs and BCRs for implementation uncertainty. Distributional effects were mapped qualitatively to stakeholder groups (consumers, manufacturers, governments, and communities) to highlight equity outcomes.

**Table 1: Summary of policies and their implementation in model**

| Policy Name | Policy Description | Policy Action | Purpose | Model implementation | BEV sales overtake ICEV sales (Year, t) | Fleet Share of BEVs in 2052 |
|---|---|---|---|---|---|---|
| **Base Case** | | No further action | | No changes to base set up | 2042 (t =76) | 62.6% |
| **BEV-REBATE** | One-time purchase rebate for new BEVs, sufficient to motivate the switch to BEVs over given period | $7,000 rebate for new BEVs.<br>5-year policy | Reduce high upfront cost for ZEV adoption to meet sustainability targets | a. ↓ upfront cost for BEVs ($7,000)<br>b. ↑ familiarity (by 5 yrs) | 2040 (t =70) | 68.6% |
| **PRIVATE CHARGER** | One-time rebate for every BEV owner for purchase or installation of smart charging devices over given period | $2,000 for smart charger installation per BEV owner<br>30-year policy | Reduce charge anxiety, reduce annual costs & improve home energy efficiency | a. ↓ annual cost reduced (20%).<br>b. ↑ familiarity (by 4 yrs)<br>c. ↑rate of charge time (100%) for BEVs, PHEVs | 2038 (t =65) | 72.0% |
| **PUBLIC CHARGER** | Recurring incentives for each installation of public fast-charging infrastructure | $15,000 per fast public charger<br>10-year policy | Reduce charge anxiety especially on long distance travel | a. ↑ charge station density growth by 20%<br>b. ↑ familiarity (by 2 yrs)<br>c. ↑rate of charge time (100%) for BEVs, PHEVs | 2041 (t =74) | 64.0% |
| **OTHER INCENTIVES** | Other recurring incentives such as toll waivers and parking fee waivers over a given period | $300 operating cost incentive (tolls etc.,) per BEV owner.<br>10-year policy | Preferential treatment for vehicles with lower tail-pipe emissions | a. ↓ annual cost growth rate (20%).<br>b. ↑ familiarity (by 2 yrs) | 2041 (t=73) | 65.5% |
| **EXPOSURE** | Investment in exposure and educational programme and events over a given period | $50 million education and public exposure<br>5-year policy | To increase public awareness & promote ZEV uptake, including in corporate & council fleets. | a. ↑ familiarity (by 2 yrs) | 2041 (t=74) | 64.5% |
| **FES** | Establish Fuel Efficiency Standards (FES) and continued improvement of these standards | Implement and manage Fuel Efficiency Standard<br>30-year policy | To increase supply of EVs, and thereby increase sales of EVs & reduce emissions from all types of cars | a. ↑ familiarity (by 1 yr)<br>b. ↑ upfront cost improvement rate - BEVs, PHEVs (35%)<br>c. ↓ Annual cost of growth for HEV, ICEV (5%) | 2041 (t=74) | 63.5% |

# 3 Key Findings and Discussion

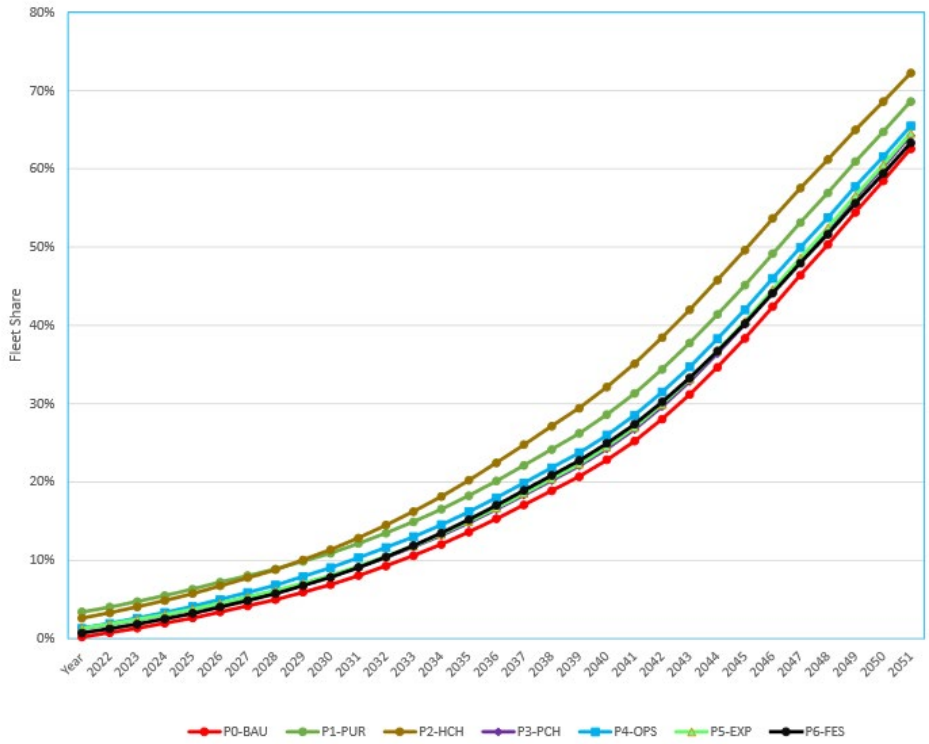


**Figure 1: BEV fleet share for BAU and 6 policies (2023 to 2052)**

**Table 2: Summary BCA results (with sensitivity, risk & distribution analysis & BEV projection)**

| Policy | BEV-REBATE $7K BEV Purchase rebate 5 yrs | PRIVATE CHARGER $2K charger rebate 30 yrs | PUBLIC CHARGER $15K Public charger rebate 10 yrs | OTHER INCENTIVES $300 Operating cost rebate 10 yrs | EXPOSURE $50m Exposure over 5 years | EMISSIONS STANDARD FES - $30m over 30 yrs |
|---|---|---|---|---|---|---|
| Total Benefits (mean) | 7.66 B | 23.54 B | 0.61 B | 2.44 B | 0.16 B | 0.83 B |
| Total Costs (mean) | 8.71 B | 12.49 B | 0.64 B | 2.73 B | 0.05 B | 0.02 B |
| NPV (5th Percentile) | -1.71 B | 5.69 B | -0.83 B | -0.98 B | -0.59 B | 0.13 B |
| NPV (mean value) | -1.06 B | 11.05 B | -0.02 B | -0.29 B | 0.11 B | 0.82 B |
| NPV (95th Percentile) | -0.30 B | 17.66 B | 0.80 B | 0.41 B | 0.83 B | 1.57 B |
| BCR (5th Percentile) | 0.79 | 1.67 | -0.66 | 0.60 | -9.90 | 8.45 |
| BCR (mean value) | 0.88 | 1.86 | 0.88 | 0.88 | 3.05 | 46.95 |
| BCR (95th Percentile) | 0.97 | 2.04 | 2.24 | 1.13 | 16.33 | 85.13 |
| BCR (probability < 1.0) | 98% | 0% | 53% | 79% | 39% | 3% |
| BEV shares of car fleet in 2030 (Target =14% per Graham 2023)) | 9.86% | 10.04% | 6.99% | 7.91% | 7.91% | 6.75% |
| BEV shares of car fleet in 2052 | 68.61% | 72.22% | 64.28% | 65.47% | 64.55% | 63.29% |
| Emissions reduction goal achieved by 2030 (% of 18MtCO2-e) | 20.3% | 20.47% | 14.56% | 15.68% | 14.66% | 14.27% |
| Emission Benefit/Total Benefit (mean) | 5.2% | 0.74% | 7.10% | 3.70% | 47.27% | 5.80% |
| Risk Analysis: Estimated Risk adjusted NPV and BCR by Policy | | | | | | |
| Risk Adjusted NPV | -0.90 B | 7.55 B | -0.020 B | -0.25 B | 0.10 B | 0.59 B |
| Risk Adjusted BCR | 0.75 | 1.27 | 0.75 | 0.75 | 2.71 | 33.84 |
| Distribution Analysis: Estimate of Tax Dollar Benefits by Stakeholder and Policy | | | | | | |
| Overseas Manufacturers/ Suppliers | 5% | | 10% | | 5% | |
| Loal Manufacturers/ Dealers | 5% | 10% | 80% | | 5% | 5% |
| Australian Consumers | 90% | 80% | 10% | 100% | 75% | 80% |
| Australian Government | | 10% | | | 5% | 5% |
| Local residents | | | | | 5% | |
| General community | | | | | 5% | 10% |

The results show that regulatory, infrastructural, and informational levers operate through distinct pathways. Quantitative and qualitative outcomes are summarised below for each policy scenario.

**BEV REBATE.** This policy of BEV purchase rebates generated the lowest NPV (–A$1 billion) and a BCR below 1, reflecting high fiscal cost and significant free-rider effects. Although it accelerates initial adoption, the effect tapers as prices converge naturally. Sensitivity analysis of rebate amounts or time period did not improve performance. The rebate primarily benefits higher-income early adopters, offering limited equity benefits or long-term efficiency gains.

**PRIVATE CHARGER**. Rebates for private smart charger purchase/installations achieved the strongest adoption and emissions-reduction effects, with an NPV exceeding A$11 billion and a BCR of 1.86. By lowering perceived risk and increasing convenience, it promotes durable behaviour change and amplifies network effects. The policy also supports distributional fairness when paired with landlord or strata incentives for shared installations.

**PUBLIC CHARGER.** Incentives for public chargers gave weak BCR (0.88) but the policy is strong on social equity, supporting renters and others who lack home-charging access. Sensitivity analysis suggests that earlier and higher incentives could produce better financial returns. Experts emphasized that these investments serve as symbolic signals of government commitment and equity instruments that extend accessibility beyond metropolitan areas, making them indispensable for the diffusion process even when direct fiscal returns are limited.

**OTHER INCENTIVES**. Registration or road-tax rebates show relatively weak fiscal performance (BCR = 0.88). Qualitative findings show that these schemes are often administratively complex. The policy is best reserved for subnational schemes where it can be contextually relevant. Overall, this policy offers limited standalone impact but may function well as a complementary measure.

**EXPOSURE.** These programs achieve lower absolute NPVs but high cost-effectiveness, with BCRs exceeding 3 under conservative assumptions. They significantly increase familiarity and reduce perceived technological and financial risk, thereby magnifying the effects of other policies. When bundled with charger programs, they shorten diffusion lags. As battery capacities grow, BEVs will be central to Australia's energy future but carry risks from poor V2X integration. Education and awareness can mitigate these risks and boost both uptake and energy system efficiency.

**FES.** The FES delivers the highest BCR (≈ 47), confirming its efficiency as a supply-side instrument. As a technology-neutral regulation, Australia’s version of FES, the New Vehicle Efficiency Standard (NVES) promotes improvements across ICEVs, FCEVs and BEVs, broadening its reach but limiting its value as a dedicated BEV policy. Its effectiveness depends on targeting high-emission vehicles and avoiding exemptions or delays, which would erode both environmental and economic benefits. When combined with demand-side policies, it anchors a sustainable, least-cost trajectory to net-zero targets.

Overall, the evidence suggests that no single policy on its own can both achieve net-zero targets and be economically efficient. This supports a portfolio approach: adopt FES to establish efficient supply-side pressure; pair with private charger rebates to unlock household adoption at scale; ensure targeted public charging to maintain equity and regional connectivity; and exposure campaigns to accelerate familiarity and reduce perceived risk. Purchase rebates give weak returns on public investment and, if used, should be time-limited or tightly targeted (e.g. low-income) to reduce free-riding, while operating-cost incentives should be used sparingly at the subnational level. Equity and implementation quality are central to success. Public charging is essential for households without off-street parking and for regional mobility; private charger rebates must be inclusive of multi-unit dwellings and office/work spaces. Monte Carlo tests show rankings remain robust to plausible parameter variations, driven mainly by BEV cost and adoption projections.

# 4 Conclusion

This study applied a three-stage framework—Delphi-based policy selection, behavioural adoption modelling, and benefit–cost analysis—to evaluate six BEV policies for Australia, offering a replicable

approach to evidence-based decarbonisation. Results confirm the fuel-efficiency standard as the most cost-efficient instrument among those considered. Australia has now implemented this as the NVES, albeit as one of the last OECD countries to do so. Next, home-charger rebates and exposure campaigns deliver the best return on public investment, adoption and emissions gains. Public charger incentives remain essential for equity and regional access, and BEV purchase rebates which are not cost efficient, if considered, should be targeted and time-bound to avoid free-riding. The framework's integration of behavioural realism, risk adjustment, and distributional analysis enhances its policy relevance. Despite limitations in dynamic policy interactions and evolving technology assumptions, the findings underscore the need for adaptive, portfolio-based strategies that balance fiscal prudence with inclusive, low-carbon mobility transitions.

## References

Anilan, V., Vij, A., Connor, J., Barrie, H. & Ardeshiri, A. (2025) Evaluating battery electric vehicle policies: a benefit–cost analysis framework. Transportation. https://doi.org/10.1007/s11116-025-10690-x

Anilan, V. & Vij, A. (2024) Taking the wheel: A systematic review of reviews of policies promoting BEVs. Transportation Research Part D.

Bass, F.M. (1969) A new product growth model for consumer durables. Management Science, 15(5), 215–227.

Burra, L.T., Sommer, S. & Vance, C. (2024) Free-ridership in subsidies for company and private electric vehicles. Energy Economics, 131, 107333.

Higgins, A. et al. (2012) Combining diffusion theory and multi-criteria analysis to simulate BEV adoption pathways. Energy Policy, 48, 483–492.

Noel, L., Zarazua de Rubens, G., Kester, J. & Sovacool, B. (2019) Fear and loathing of electric vehicles: the reactionary rhetoric of range anxiety. Energy Research & Social Science, 48, 96–107.

Rietmann, N. & Lieven, T. (2019) How policy measures succeeded in supporting electric vehicle adoption. Transportation Research Part A, 124, 149–163.

Song, R. & Potoglou, D. (2020) Drivers of electric vehicle uptake in international markets. Renewable and Sustainable Energy Reviews, 119, 109624.

Wang, N., Tang, L. & Pan, H. (2019) A global comparison and policy implications for electric vehicle adoption. Energy Policy, 132, 267–278.

Xue, C. et al. (2021) Evaluating national policies for electric vehicle promotion. Transportation Research Part D, 94, 102813.