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Economic Viability of Vehicle-to-Vehicle Energy Trading in EV Charging Ecosystems

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ABSTRACT

This study investigates the economic feasibility of Vehicle-to-Vehicle (V2V) energy trading from the perspective of electric vehicle (EV) owners acting as energy providers. A milestone has been achieved due to advancements in technology in bidirectional charging systems. However, the profitability of peer-to-peer energy transfers remains underexplored. In this study, a return on investment (ROI) framework is developed in MATLAB/Simulink, which incorporates battery degradation costs, variable energy pricing (flat and time-of-use), and controlled discharge profiles. Simulation results using a 48 V, 100 Ah lithium-ion battery reveal that ROI is most sensitive to V2V sale price and battery cost, while charging tariff exerts limited influence. Break-even analysis shows that ROI becomes positive when sales price exceeds R3.60/kWh or battery cost drops below R14,000. Furthermore, three-dimensional sensitivity surfaces confirm that the economic viability of V2V energy exchange is primarily constrained by capital cost and revenue dynamics. These findings provide actionable insights for designing market-driven V2V frameworks and guiding policy interventions aimed at promoting distributed energy sharing.

Keywords: Energy Trading, V2V, ROI, Degradation Cost, Break-Even Points
JEL Classifications: C6, L9, N7, R4

1. INTRODUCTION

The transition to electric vehicles (EVs) is accelerating globally as part of the broader movement toward sustainable transportation and reduced greenhouse gas emissions (Kumar et al., 2024). However, the high rate of its adoption has placed significant pressure on existing electric vehicle charging infrastructures, especially in regions with limited grid capacity or frequent energy supply disruptions (Somefun and Longe, 2025). One promising solution to alleviate such strain is the integration of Vehicle-to-Vehicle (V2V) energy exchange, where EVs with surplus battery energy supply power directly to other EVs in need (Somefun and Longe, 2025).

V2V charging has primarily been explored from a technical and operational standpoint emphasizing power flow coordination, battery management, and system control (Somefun and Longe, 2025). While these studies have contributed to understanding the feasibility of V2V implementation, the economic implications for participating EV owners remain as a gap in the current published open literature. For EV owners to willingly participate in energy sharing, they must be assured of economic gains that justify the associated energy losses, battery degradation, and time commitment.

A critical factor influencing participation is the Return on Investment (ROI). How much financial benefit can an EV owner expect by discharging its battery to charge another EV? Unlike centralized charging stations where revenue is collected by service providers, V2V introduces a peer-to-peer trading dynamic, raising questions around pricing models, fair compensation, and the impact of repeated discharging on battery longevity.

Building upon the authors' earlier work that introduced a V2V-enabled EV charging framework for energy-shortage charging stations (Somefun and Longe, 2025), this study shifts the focus to a key economic inquiry: under what condition(s) does V2V energy trading become financially viable for energy-selling EV owners? We present an economic model that incorporates energy transfer pricing, battery cycle life reduction, and transaction overheads to assess ROI in various trading scenarios. Through simulation-based analysis, we aim to provide insights into the profitability thresholds, break-even points, and policy considerations that support sustainable V2V energy ecosystems.

The remainder of this paper is structured as follows: Section 2 presents the literature review; Section 3 outlines the methodology; Section 4 discusses the results and their policy implications; and Section 5 concludes with key findings from the study.

2. LITERATURE REVIEW

The evolution of electric vehicle (EV) infrastructure has spurred research in various aspects of energy exchange, particularly Vehicle-to-Everything (V2X) technologies, including Vehicle-to-Grid (V2G), Vehicle-to-Building (V2B), and Vehicle-to-Vehicle (V2V) systems (Borge-Diez et al., 2021; Noel et al. 2019; Somefun and Longe, 2025; Tariq and Ahanger, 2025). While the benefits of technical feasibility and grid stability of such systems are being studied, the economic incentives for battery owners within V2V configurations, remain underexplored. This section critically examines relevant research contributions in relation to V2V energy exchange, battery degradation costs, economic modelling frameworks, and pricing strategies for V2V energy exchange systems.

2.1. V2V Energy Exchange Models

Several studies have proposed V2V energy sharing as a decentralized solution for flexible and resilient EV charging. For example, Shurrab et al. (2021) proposed an efficient V2V energy sharing framework that leverages control algorithms to optimize donor-recipient matching based on SOC and spatial proximity. However, their work focused mainly on control dynamics and energy optimization rather than economic outcomes. Similarly, Liu et al. (2013) highlighted the role of V2V/V2G in mitigating grid loads but acknowledged the need for economic modelling in future work. In another context, Amirioun and Kazemi (2014) presented an optimal scheduling model combining V2V and V2G interactions within residential energy networks; yet, their analysis was primarily technical, without estimating monetary gains or losses for participants.

2.2. Battery Degradation and Financial Cost

Battery degradation is a key economic factor in V2X operations. Liu et al. (2019) developed a coupled electrothermal-aging model to minimize battery aging and energy loss during charging. Iwafune and Ogimoto (2020) showed how demand response (DR) strategies that account for degradation can reduce household electricity costs. Schade and Egging-Bratseth, (2024) quantified the impact of degradation on dispatch economics for stationary storage. However, these studies do not analyse mobile V2V trading scenarios or address how degradation affects profitability for donor EVs. Han et al. (2012) modelled profitability for V2G frequency regulation, but under utility-controlled frameworks. Similarly, Englberger et al. (2019); Ghaderi and Nassiraei (2015) simulated battery wear in V2B models, while Thompson (2018) broadly reviewed battery degradation across V2X services without simulating V2V ROI. Perez et al. (2016) also evaluated service portfolios under degradation, but with no focus on EV-based peer-to-peer exchanges. This research builds on these works by applying degradation modelling directly to V2V contexts and quantifying ROI under realistic pricing and usage conditions.

2.3. Economic Modelling and ROI Frameworks

Several authors have developed models to quantify economic feasibility of V2X energy systems. Das et al. (2013) introduced compensation schemes for battery capacity loss in V2G, while Liu and Zhong, (2019) analysed Electric Vehicle-distributed renewable energy (EV-DRE) coordination with lifecycle cost metrics. However, neither study considered peer-level interactions or V2V. Although Ghaderi and Nassiraei (2015) implemented a MATLAB/Simulink simulation for V2B profitability, and Thompson (2018) discussed economic modelling across V2X platforms, but of them both lacked specific attention to decentralized V2V trade or donor-side ROI. In contrast, this study presents a simulation-based ROI model incorporating battery wear costs, discharge frequency, and break-even thresholds specific to EV owners engaged in peer-to-peer energy trading.

2.4. Pricing Strategies and Trading Mechanisms

Pricing strategies are central to incentivizing participation in decentralized energy systems. Lv et al. (2023) optimized pricing across charging networks using an augmented user equilibrium model, and Amirioun and Kazemi (2014) proposed coordinated scheduling strategies combining V2G and V2V with distributed energy resources (DERs). George-Williams et al. (2022) focused on system-level coordination in smart hubs. While these studies present valuable insights into centralized or aggregator-level trading strategies, they do not account for owner-centric pricing models or evaluate profit margins for peer-to-peer or V2V trades. This research addresses that gap by evaluating flat-rate and time-of-use pricing schemes from the perspective of donor EV owners, linking profitability directly to pricing dynamics and battery lifecycle costs.

3. METHODOLOGY

This section outlines the approach used to evaluate the economic viability and return on investment (ROI) for Vehicle-to-Vehicle (V2V) energy trade. The methodology integrates energy pricing models, a cost-per-cycle battery degradation model, and economic analysis metrics. The system is modelled and simulated using 2025a MATLAB/Simulink version. The key components and subsystems include:

i. Battery modelling: A 48 V, 100 Ah lithium-ion battery is implemented using Simscape's table-based battery block to represent the energy-discharging EV in the V2V exchange. The receiving EV is modelled as a controlled current load, allowing flexible simulation of energy transfer scenarios
ii. Energy flow logic: Integrator blocks and enabled subsystems are used to accumulate total energy transferred (in kWh),

energy charged, and energy discharged, ensuring accurate time-domain accounting

iii. Revenue and cost modelling: Constant blocks, arithmetic functions, and gain blocks are used to compute charging costs, battery degradation costs (based on price per kWh cycled), and V2V revenue. These are combined to calculate ROI in real-time

iv. Pricing strategy implementation: Lookup tables and Dashboard blocks enable user-controlled pricing configurations, allowing for both flat-rate and time-of-use (ToU) tariff simulations

v. Control input: A controlled current source is driven by a user-defined profile or slider-controlled logic to simulate dynamic charging and discharging behaviour under SOC constraints

vi. Monitoring and visualization: Scopes, display blocks, and Dashboard gauges track key signals including current, voltage, SOC, energy traded, revenue, and ROI over time

vii. Sensitivity analysis tools: Slider Gain and Manual Switch blocks allow live variation of key parameters (e.g., battery cost, sale price), while simulation scripts enable batch analysis and surface plotting.

Simulations are conducted for South African time-of-use (ToU) pricing and inclining block tariff pricing strategies (City Power, 2025). For this study, the inclining block tariff is taking as flat-rate since one single battery is considered which falls on block 1 energy usage (City Power, 2025).

A 48 V, 100 Ah lithium-ion battery is adopted as the donor energy source for our model. This capacity provides 4.8 kWh of nominal energy per full discharge. The energy transfer system includes logical switching mechanisms governed by SOC thresholds.

3.1. Energy Transfer and Pricing Models

Since 1 joule = 1/3,600,000 kWh, therefore, the energy transferred E in a given time t is calculated as:

$$E(t) = \frac{V \times I(t) \times \Delta t}{3,600,000} \quad kWh \tag{1}$$

Where: V is the battery voltage, I(t) is the discharge current, Δt is the simulation time step in seconds.

The revenue generated from each energy exchange is given by:

- Flat-rate pricing:

$$Revenue_{flat} = E(t) \times P_{fixed} \tag{2}$$

- Time-of-Use pricing:

Revenue(TOU) = Revenue(peak) + Revenue(standard) + Revenue(off-peak)

$$Revenue_{TOU} = (E_{peak} \times P_{peak}) + (E_{standard} \times P_{standard}) + (E_{off\text{-}peak} \times P_{off\text{-}peak}) \tag{3}$$

Where: P_{fixed} is the flat rate or inclining block tariffs per kWh (e.g., R2.01 at Gauteng Province) for energy ≤350 kWh (South Africa Electricity Tariffs, 2025).

P_{peak}, $P_{standard}$, and $P_{off\text{-}peak}$ are the ToU peak, standard, and off-peak tariffs, respectively. Table 1 shows ToU tariff deployed in this study as obtained from City Power (2025).

Table 1: Time-of-use tariff plan for weekdays (City Power, 2025)

Time period	Summer rate (R/kWh)	Winter rate (R/kWh)	Duration
Peak	R2.76	R6.34	7 am-10 am, 6 pm-8 pm
Standard	R2.18	R2.59	6 am-7 am, 10 am-6 pm, 8 pm-10 pm
Off-Peak	R1.71	R1.83	10 pm-6 am

3.2. Battery Degradation Cost Model

Battery degradation is accounted for using a cost-per-cycle model. Each full discharge counts as one full cycle, and partial cycles are weighted accordingly with respect to its depth of discharge (DoD).

$$Degradation\,Cost = \frac{C_{battery}}{N_{cycles} \times B_{Capacity}} \tag{4}$$

Where: $C_{battery}$ = cost of the battery in (R), N_{cycles} = expected total number of full charge-discharge cycles, and $B_{Capacity}$ = battery capacity in (kWh). Table 2 shows four different prices range deployed in this study to determine battery cost effect on return on investment.

3.3. Return on Investment (ROI) Calculation

The Return on Investment (ROI) is a key metric used to evaluate the economic viability of discharging an EV battery to supply energy to another vehicle. It is calculated as follows:

$$ROI = \frac{Revenue - \left(Degradation\,Cost + P_{Charging\,Cost}\right)}{C_{battery}} \tag{5}$$

Where:

Revenue is the sum of all earnings from energy sales per day, *Degradation Cost* is the sum of wear costs based on total energy discharged per day, and

$P_{ChargingCost}$ is the cost at which EV owner buy energy before engaging in V2V energy transaction.

3.4. Break-even Energy Requirement

To evaluate the economic viability of V2V energy trading, it is essential to determine the break-even energy threshold, which accounts for both the cost of battery degradation and the cost of charging the battery before energy is resold via the V2V platform. The break-even energy required to recover the battery's initial cost is calculated as follows:

$$Break\text{-}even\ Energy\ (kWh) = \frac{C_{battery}}{P_{net}} \tag{6}$$

$$P_{net} = P_{sale} - \left(\frac{C_{battery}}{N_{cycle} \times B_{capacity}} + P_{Charaging\,Cost/kWh}\right) \tag{7}$$

Where:

P_{sale} = Sale price per unit of energy (R/kWh); and P_{net} = Net revenue (R/kWh)

This model provides a practical threshold for determining the minimum energy trading volume required to reach a financial break-even point. A positive P_{net} value is necessary to ensure economic viability. If $P_{net} \leq 0$, the energy sale is economically unsustainable under the given pricing and battery degradation conditions. Therefore, to ensure a financially sustainable V2V energy exchange, the sale price must sufficiently exceed both the battery's marginal degradation cost and the cost of recharging.

3.5. Sensitivity Analysis

To assess how key variables influence economic viability, sensitivity analyses were conducted by varying: sale price per kWh, battery cost, and charging tariff.

Sensitivity is quantified by:

$$Sensitivity_x = \frac{\Delta ROI}{\Delta x} \tag{8}$$

Where x is one of the three factors listed above (sale price, battery cost, and charging tariff). This allows the model to identify conditions under which V2V energy trading is economically feasible.

The simulation model is shown in Figure 1, and it is customised to real-time simulation results by introducing an interactive dashboard to monitor the battery SOC, adjust the selling as per ToU, visualise the battery health state, and also revenue per sale as shown in Figure 2.

The simulation is carried out using constant current charging approach so that the system response can be quickly observed on the dashboard. A detailed controlled of EV charging system can be found in (Somefun and Longe, 2025).

4. RESULTS AND DISCUSSION

This section presents the results of simulation-based analysis for assessing the economic performance of V2V energy trading from the perspective of a battery owner. The analysis includes total energy transferred, revenue earned, battery degradation cost, return on investment (ROI), break-even points, and sensitivity of ROI to key parameters. In this study, "break-even" is defined as the point at which the total revenue generated from V2V energy trading is exactly equal to the incurred battery degradation cost and charging cost. At this point, the return on investment (ROI) is approximately zero, indicating neither profit nor loss. Values of ROI above zero reflect financially beneficial trading, while values below zero imply a net economic loss.

Figure 3 presents the simulation results of the V2V-ROI Model during two full charge–discharge cycles under constant current

Table 2: 48 V 100 Ah Lithium-ion batteries prices (AmoSolar, 2025; Fivestar, 2025; Sungod, 2025; Takealot Store, 2025)

Feature	Battery supplier 1	Battery supplier 2	Battery supplier 3	Battery supplier 4
Battery type	Lifepo4 Lithium-ion	Lithium-ion	Lithium-ion LifeP04	Lithium-ion
Price	Original price was R16,590.00	R15990,00	R10,800.00	R19,610.00
Cycle life	6000	N/A	6000	6000+
Warranty	N/A	N/A	36 months	48 months

Figure 1: MATLAB/Simulink connection simulation model for V2V energy exchange

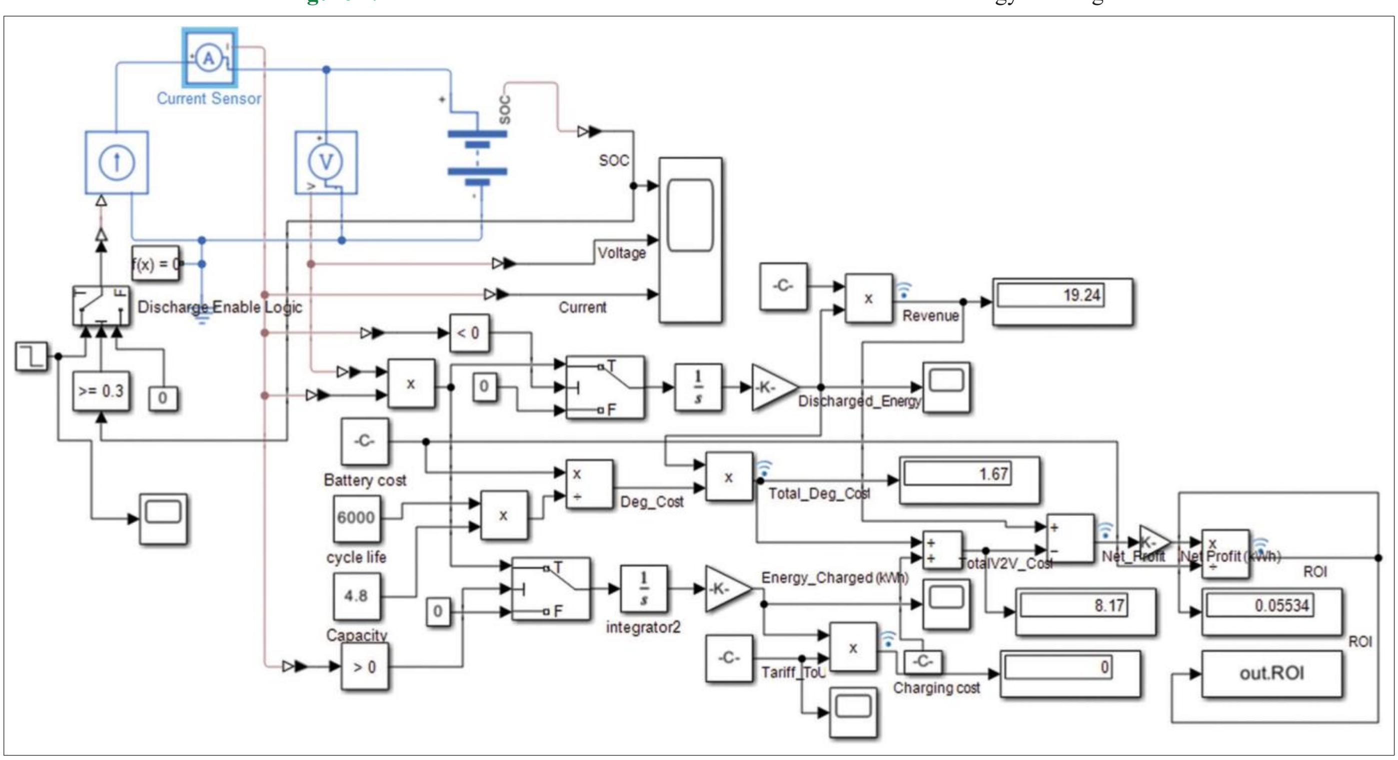


Figure 2: V2V-ROI Interactive dashboard Simulation model

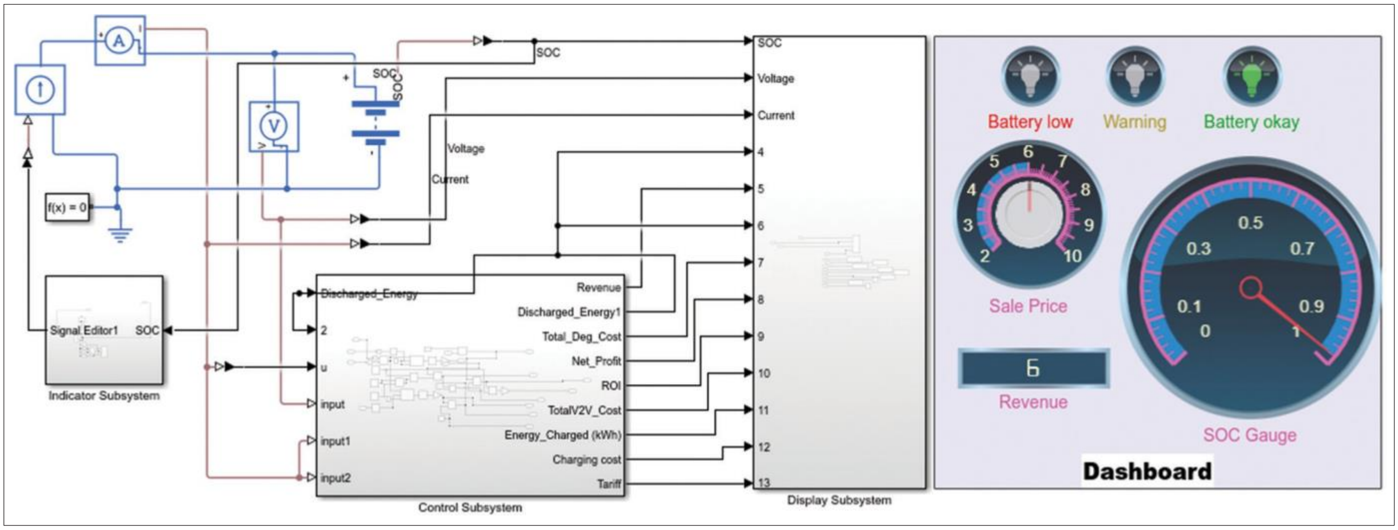
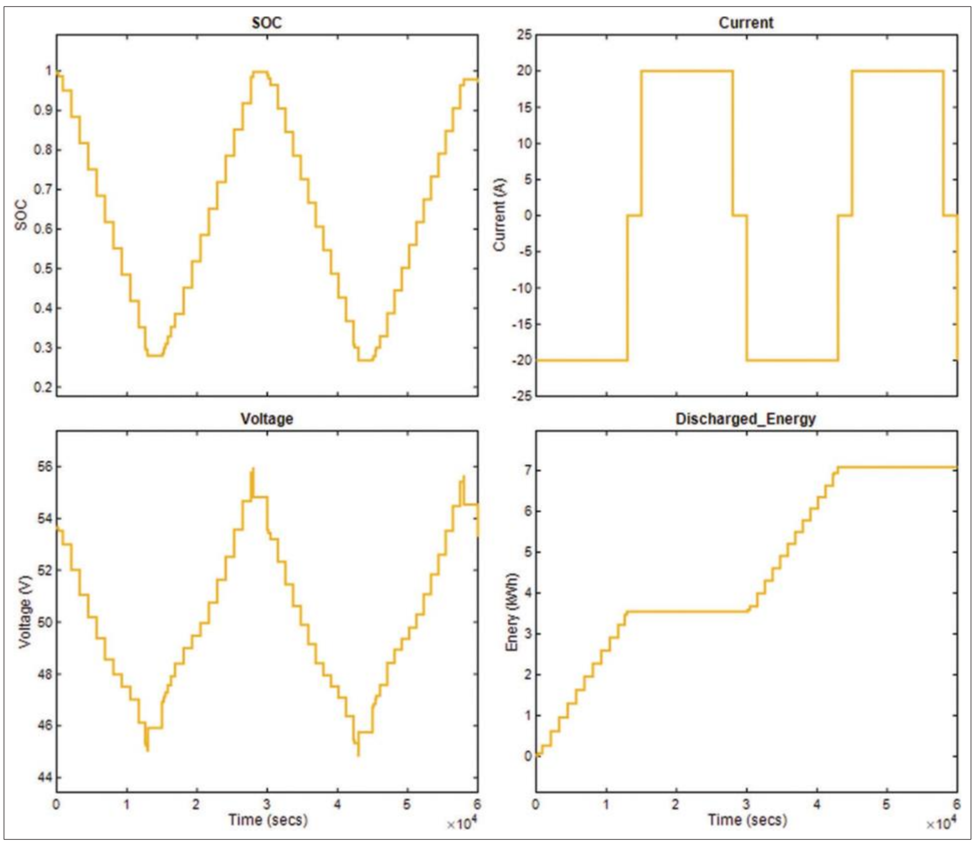


Figure 3: Simulation results of the V2V-ROI Model showing SOC, current



operation. Each cycle begins with battery discharge during V2V operation, followed by charging from the grid (G2V). The SOC trace (top-left) clearly shows periodic declines and recoveries, with discharging limited by a lower SOC threshold of 0.3 and charging extending toward full capacity. This SOC-boundary logic prevents over-discharge and reflects realistic battery protection constraints in energy trading applications. The current waveform (top-right) alternates between +20 A (charging) and −20 A (discharging), confirming the bidirectional energy flow. Sharp transitions between current levels represent the switching points between G2V and V2V phases. In the voltage profile (bottom-left), the battery voltage dynamically responds to SOC, dropping as the battery discharges and recovering during charging. These variations directly influence instantaneous power, and, by extension, the energy accumulated during each V2V phase. Most critically, the discharged energy curve (bottom-right) shows a staircase pattern, increasing only during discharge intervals and holding steady during charging. This confirms the correct use of enabled integration, ensuring only V2V energy transfers contribute to revenue calculations.

4.1. Analysis of Economic Viability of V2V Energy Exchange

To evaluate the economic viability of vehicle-to-vehicle (V2V) energy trading, return on investment (ROI) was analysed under three core simulation scenarios and three extended sensitivity surfaces:

i. Scenario 1: The charging tariff is varied from R0.00 to R6.50, while the V2V selling price and the battery cost (48 V, 100 Ah) are held constant at R7.00 and R13,990, respectively
ii. Scenario 2: The battery cost is varied from R5,000 to R20,000, with the charging tariff fixed at R1.83 (winter off-peak rate) and the V2V selling price held at R5.00
iii. Scenario 3: The V2V selling price is varied from R1.73 to R6.34 (aligned with time-of-use pricing), while the charging tariff and battery cost remain fixed at R1.83 and R13,990, respectively.

Figure 4 depicts scenario 1 in which the resulting ROI remained relatively flat and positive across the charging tariff range, indicating that under high sale prices, profitability is largely unaffected by charging tariff fluctuations. Scenario 2 which is depicted in Figure 5, examined the effect of battery cost variation on ROI. The ROI decreased nonlinearly with increasing battery cost. This suggests that systems with high battery capital costs are unlikely to be profitable without external incentives. Figure 6 illustrates the relationship between the vehicle-to-vehicle (V2V) energy sale price and the resulting return on investment (ROI) under Scenario 3, where both the battery cost and charging tariff are held constant. The ROI increases linearly with the sale price, indicating a directly proportional relationship. The break-even point where ROI transitions from negative to positive occurs at approximately R3.60/kWh. This implies that for V2V trading to be economically viable, the energy must be sold at or above R3.60/kWh. Below this threshold, the revenue generated is insufficient to offset the battery degradation and energy acquisition costs.

To further explore the interaction between variables, 3D sensitivity surfaces were generated. Figure 7 plots ROI against battery cost and sale price under varying charging tariff. ROI increases significantly with higher sale prices and lower battery costs, while changes in tariffs have a negligible influence. The break-even contour shifts upward with increasing battery cost, showing that profitability is only achieved at higher sale prices when investment is high. Figure 8 shows ROI as a function of sale price and charging tariff under different battery cost levels. The ROI surface reveals that break-even is easily reached at moderate sale prices if battery costs are low; however, as battery cost increases, the required sale price for break-even rises steeply. Figure 9 presents ROI in terms of battery cost and charging tariff, layered by fixed sale price. The ROI rapidly drops below zero when battery cost exceeds R14,000 for sale prices below R4.00, indicating that only high sale prices can offset elevated capital costs. In all cases, break-even analysis confirms that battery investment and V2V sale price are the primary economic levers, while charging tariff plays a secondary role.

Table 3 summarizes the critical sale price, battery cost, and charging tariff levels at which ROI transitions from negative to positive, under various simulation configurations.

Figure 4: ROI response to charging tariff

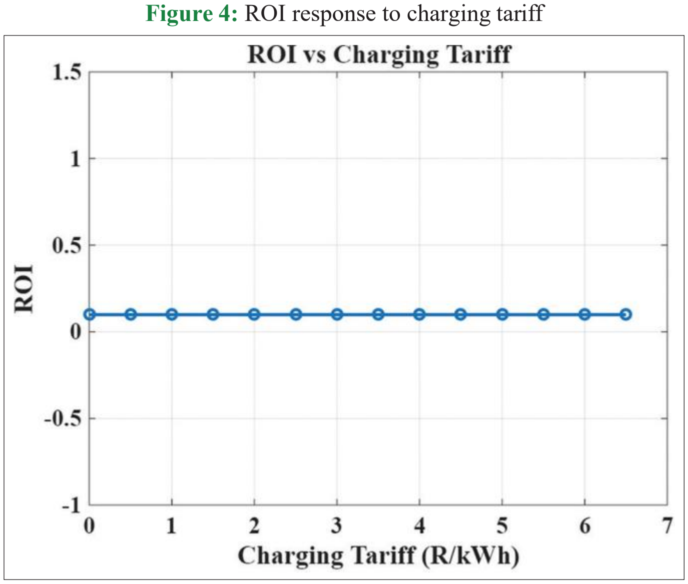


Figure 5: ROI response to battery cost

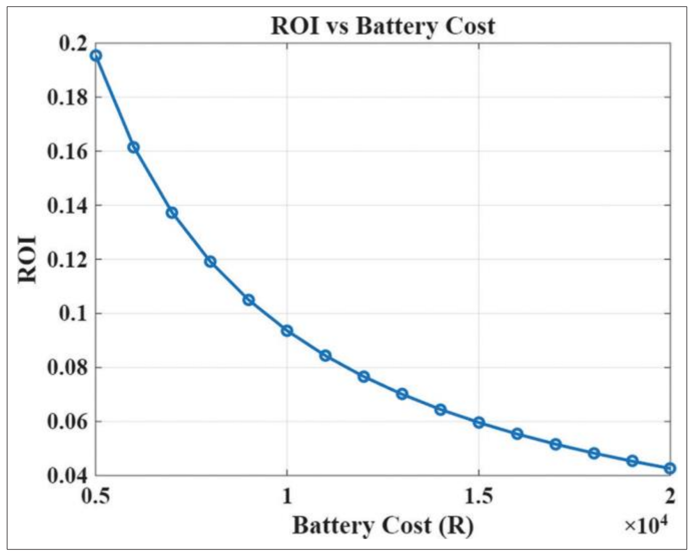


Figure 6: ROI response to V2V selling price

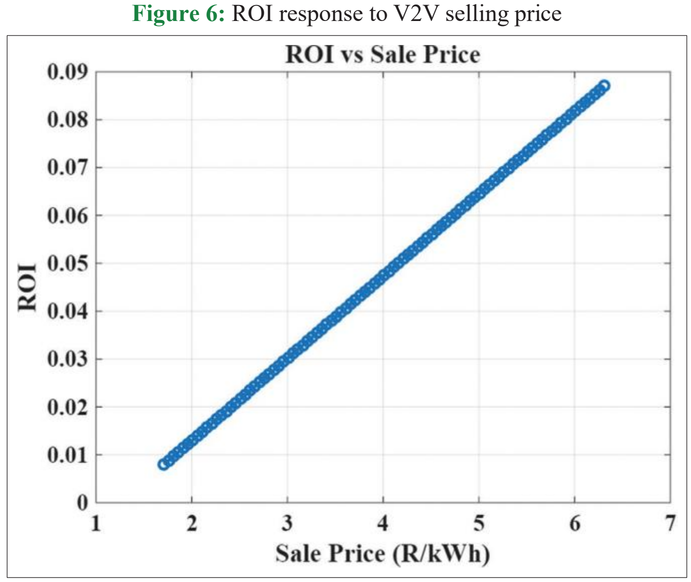


Figure 7: ROI versus battery cost and sale price

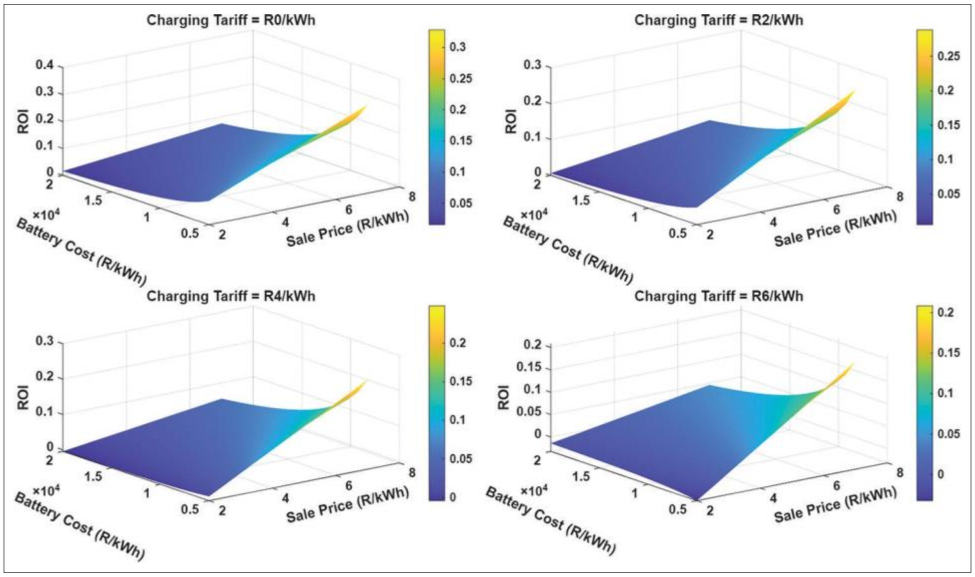


Figure 8: ROI versus charging tariff and sale price

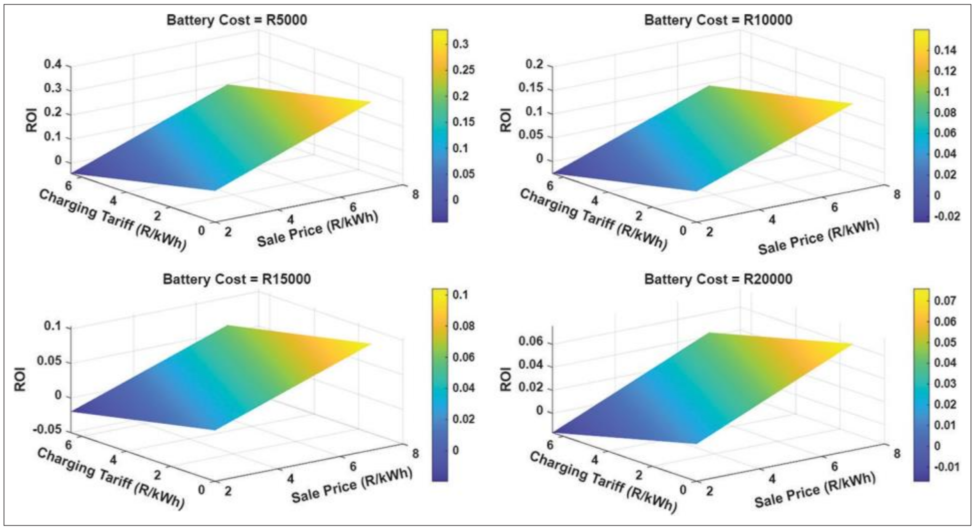


Figure 9: ROI versus battery cost and charging tariff

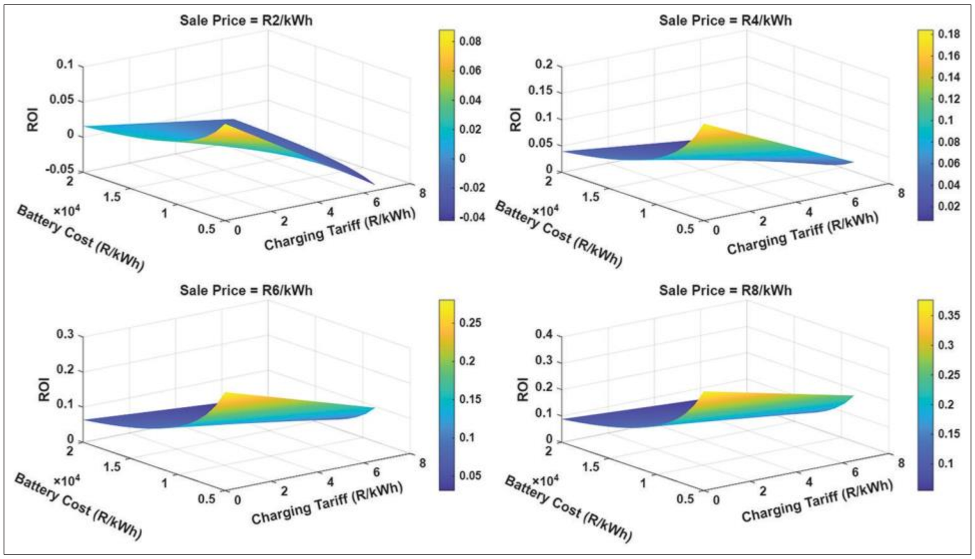


Table 3: Parameter thresholds at which V2V trading breaks even

Scenario/Plot	Break-Even Threshold	Fixed Parameters	Comment
Figure 4: ROI versus Charging Tariff	ROI remains >0 across R0.00-R6.50	Battery Cost: R13,990 Sale Price: R7.00	V2V trading is always profitable under this sale price, even with high charging tariffs.
Figure 5: ROI versus Battery Cost	ROI≈0 at Battery Cost≈R17,500	Charging Tariff: R1.83 Sale Price: R5.00	Beyond R17,500, battery cost outweighs revenue, making trading unviable.
Figure 6: ROI versus Sale Price	ROI≈0 at Sale Price≈R3.60	Battery Cost: R13,990 Charging Tariff: R1.83	R3.60 is the minimum price needed to offset degradation and charging costs.
Figure 7: ROI versus Battery Cost and Sale Price	Break-even line rises with battery cost: Sale Price ≥R4.00 when Battery Cost ≥R13,000	Tariff: layered (0-6.5)	Higher battery costs demand higher V2V selling prices for break-even or profit.
Figure 8: ROI versus Charging Tariff and Sale Price	Sale Price must exceed R3.80 for Battery Cost=R10,000. Break-even shifts right for higher Battery Cost	Battery Cost: layered (R5,000-R20,000)	Increased charging tariffs reduce ROI unless compensated by higher sale prices.
Figure 9: ROI versus Battery Cost and Charging Tariff	Break-even at Battery Cost≈R14,000 when Sale Price=R4.00. No break-even for lower sale prices (e.g., R2.00)	Sale Price: layered (R2.00-R6.00)	At low sale prices (e.g., R2.00), V2V trading is economically unviable regardless of battery cost.

4.2. Policy Implications Based on Break-Even Analysis

The break-even thresholds derived from the ROI simulations offer actionable insights for policymakers, battery manufacturers, energy market designers, and EV manufacturers. Notably, the analysis indicates that V2V energy trading becomes economically viable when the battery acquisition cost is below R13,000 (as shown in Figure 7) or when the sale price of energy exceeds R3.60/kWh (as indicated in Figure 6), under a typical off-peak charging tariff of R1.83/kWh. This suggests that targeted battery subsidies or cost-sharing models could significantly accelerate adoption by lowering upfront investment barriers. Additionally, enabling dynamic or premium V2V energy pricing through peer-to-peer market platforms can enhance return potential, especially for EV owners operating in regions with low Time-of-Use (ToU) grid prices. Furthermore, the analysis confirms that grid charging tariffs have a secondary effect on ROI under most conditions. Therefore, regulatory attention may be better focused on incentivizing resale pricing and battery affordability rather than adjusting EV charging tariffs. Policy mechanisms such as tax credits, leasing support, or V2V participation rewards can help bring a larger share of the EV population above the profitability threshold, supporting both energy resilience and user-level economic participation in distributed energy systems.

In addition to regulatory and pricing mechanisms, EV manufacturers have a critical role to play in enabling the viability of V2V energy trading. The simulation results highlight the importance of monitoring transferred energy and ensuring user awareness of profitability. To support this, manufacturers should consider integrating native V2V energy transfer capabilities into vehicle platforms, complete with onboard energy transaction tracking systems. This would allow EV owners to view the total energy discharged via V2V, real-time pricing, revenue accrued, and estimated ROI directly through the vehicle's infotainment system or mobile app. Such integration would enhance transparency, improve user trust, and promote widespread participation in peer-to-peer energy sharing. By embedding V2V readiness and economic monitoring as standard vehicle features, manufacturers can help unlock new business models for EV owners and contribute to the decentralization of energy services.

5. CONCLUSION

This study presented a simulation-based evaluation of the economic viability of Vehicle-to-Vehicle (V2V) energy trading, with a focus on return on investment (ROI) from the perspective of participating electric vehicle (EV) owners. Using a MATLAB/Simulink model that accounts for battery degradation cost, charging tariffs, and energy resale pricing, the ROI was assessed across multiple operational scenarios and sensitivity conditions. Key findings indicate that battery cost and V2V sale price are the dominant factors influencing ROI, while the charging tariff although often a focus of grid-side regulation has a comparatively minor effect on profitability within realistic pricing ranges. Break-even analysis revealed that ROI becomes favourable when sale prices exceed R3.60/kWh or battery costs fall below approximately R14,000, underscoring the importance of battery affordability and flexible energy pricing in making V2V models economically sustainable. Furthermore, the 3D surface plots confirmed that ROI sensitivity is strongly concentrated along the axes of sale price and capital cost, with minimal deviation along the charging tariff axis. These insights reinforce the argument that future V2V policy frameworks and platform designs should prioritize market mechanisms that support competitive resale pricing, as well as financial incentives that reduce battery investment barriers. Overall, the study offers a quantitative foundation for guiding both technology adoption and policy development in emerging V2V energy ecosystems.

Future research will extend this analysis by incorporating real-world usage profiles, multi-agent decision models, and stochastic degradation behaviour to more accurately reflect practical deployment conditions in V2V energy ecosystems.

6. FUNDING

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