Planning an Integrated Feeder System for e-BRT

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ABSTRACT

The development of an Electric Bus Rapid Transit (e-BRT) system in Sarbagita area requires the support of an integrated feeder transport system to ensure first-mile–last-mile connectivity and enhance public transport accessibility. This study aims to design feeder routes and service lines supporting the e-BRT system, analyze applicable operational systems, and evaluate financial feasibility based on Vehicle Operating Costs (VOC). A descriptive–quantitative approach was adopted, utilizing field survey data, secondary data, and public transport planning standards. The results indicate that the proposed feeder system consists of four integrated routes serving the Central Parking Kuta Station, namely FD-01 (East) with a route length of approximately 16 km, FD-02 (West) 7.3 km, FD-03 (South) 10.8 km, and FD-04 (North) 13 km (round trip). Operational analysis shows that cycle times range from 81.20 to 130.99 minutes, with fleet requirements of 9–14 vehicles and an average headway of approximately 9 minutes across all routes. From a financial perspective, total annual VOC ranges between Rp 141,335,385 and Rp 178,537,394, with the lowest operating cost per kilometer recorded on FD-01 at Rp 3,831.18/km and the highest on FD-D-02 at Rp 10,637.92/km. The VOC-based fare analysis indicates that the required operational fare ranges from Rp 11,551 to Rp 14,075 per passenger. Overall, the findings demonstrate that the proposed feeder transport system integrated with the e-BRT network is technically feasible, operationally effective, and financially viable, and has the potential to improve public transport accessibility and support the development of sustainable urban transportation.

Keywords: Feeder Transport, E-BRT, Route Planning, Operational System, Vehicle Operating Costs.

1. INTRODUCTION

The rapid growth of urban activities has significantly increased mobility demand and intensified transportation problems, particularly traffic congestion driven by the dominance of private vehicles. Badung Regency, as one of the main centers of economic activity and tourism in Bali, experiences high population density, which directly contributes to increased pressure on the road network and declining traffic performance [1]. These conditions underscore the urgent need for a reliable, integrated, and sustainable public transportation system.

The development of an electric Bus Rapid Transit (e-BRT) system in Sarbagita metropolitan area represents a strategic initiative by the Bali Provincial Government to promote low-emission transportation. However, numerous studies emphasize that the success of BRT systems is highly dependent on the availability of effective feeder services, particularly in ensuring seamless first-mile–last-mile connectivity [2]. In the absence of adequate feeder services, BRT service coverage remains limited, and public willingness to shift from private vehicles tends to be low.

Previous studies in Bali indicate that accessibility to transit stops is a key determinant of public transport usage. Surung and Arka [3], found that ease of access to Trans Sarbagita stops significantly influenced service utilization and recommended strengthening feeder services. Similarly, Nugraha et al. [4], reported a high willingness among residents in the Sarbagita area to shift to Trans Metro Dewata, indicating substantial potential for public transport as a sustainable mobility option, provided that it is supported by an integrated service system.

A number of studies have examined the planning and operation of feeder services or urban public transport; however, these analyses remain partial and context-specific. Pradnyana [5] and Ariawan [6], focused on school transport systems through route analysis, headway determination, and vehicle operating cost (VOC) evaluation, while Ananda et al. [7], developed feeder services for BRT Corridor 2 using alternative route planning and distance-based fare structures. Despite their relevance, these studies do not simultaneously integrate route and network planning with operational and financial analysis in the context of feeder services supporting electric BRT systems, particularly in Badung Regency.

Accordingly, a research gap exists in the absence of a comprehensive study that links spatial aspects (routes and service networks), operational characteristics (headway, cycle time, fleet requirements), and financial feasibility (vehicle operating costs) to support the implementation of e-BRT feeder services. This gap is particularly critical given that Law No. 22 of 2009 mandates that mass public transport systems supported by feeder services guaranteed by the central and/or local government.

To address this gap, this study proposes a novel integrated approach to planning feeder services for e-BRT systems. The proposed framework aims to develop a feeder service model that is technically feasible, operationally efficient, and financially viable, thereby providing practical relevance for sustainable transport policy formulation in rapidly developing urban areas.

Specifically, this research aims to design feeder routes and service networks that support the e-BRT system and to analyze the most appropriate operational scheme for determining fare structures. The hypothesis of this study is that feeder services integrated with the e-BRT system and designed based on demand characteristics and operating costs will enhance service accessibility, encourage modal shift from private vehicles, and be feasible for practical implementation.

2. THEORY AND METHODS

2.1 Feeder Transport Planning for e-BRT

Urban transportation plays a crucial role in supporting population mobility and economic activities; therefore, the provision of a reliable, integrated, and sustainable public transport system is essential [8,9]. Mass public transport systems such as Bus Rapid Transit (BRT) are designed to serve primary travel demand through fixed routes and schedules. However, their effectiveness is highly dependent on supporting systems that are capable of reaching residential areas and locations beyond the main corridors.

Feeder transport services are small- to medium-capacity public transport modes that function to collect and distribute passengers to and from the main transit system, thereby supporting first-mile–last-mile connectivity [10,11]. Feeder systems are typically designed to serve areas with lower population density or limited direct access to BRT corridors, creating an integrated hierarchical transport network between trunk services and supporting modes [12,13].

The development of Electric Bus Rapid Transit (e-BRT) as an electric bus–based mass transit system forms part of a broader sustainable transportation strategy aimed at reducing fossil fuel consumption and vehicle emissions. Nevertheless, without proper feeder planning, the service coverage of e-BRT remains limited, potentially reducing accessibility and public willingness to use the system. Therefore, the planning of feeder services integrated with e-BRT is a critical factor in expanding service coverage, improving system efficiency, and enhancing the overall performance of urban public transportation.

2.2 Feeder Transport Routes, Service Lines, and Stops

A public transport service line refers to the provision of transport services between a specific origin and destination, while a route represents the sequence of road segments traversed along a service line [9]. A network of service lines forms an integrated service system designed to meet urban mobility needs [14]. In feeder transport planning, route and service line determination is primarily aimed at connecting residential areas and activity centers to e-BRT stations, while accounting for trip generation and attraction, land-use patterns, and the hierarchy of the road network.

Accessibility is a key factor in determining the effectiveness of feeder services, as it reflects the ease of access to public transportation [15]. One of the main components in enhancing accessibility is the provision of public transport stops located along feeder routes. These stops serve as boarding and alighting points and must be appropriately located to facilitate intermodal transfers while minimizing traffic disruption stipulated in the Government Regulation of the Republic of Indonesia No. 14 of 1993.

The spacing between stops is influenced by travel demand levels, acceptable walking distances, and land-use characteristics. In dense mixed-use urban areas comprising residential, educational, and service functions, the recommended stop spacing ranges from 300 to 500 meters stipulated in the Department of Transportation of 1996. This spacing is considered optimal in balancing passenger convenience, travel speed, and operational efficiency.

Stop locations may be classified as near-side, far-side, or mid-block, depending on traffic conditions, pedestrian accessibility, roadway geometry, and user safety considerations [2,16]. Proper placement of stops along feeder routes plays a critical role in supporting intermodal integration and enhancing the overall performance of the e-BRT system.

2.3 Operational System of Feeder Transport Services

The planning of a feeder transport operational system aims to ensure efficient, reliable services that comply with public transport service standards [17]. The main operational indicators include load factor, vehicle capacity, cycle time, headway, and fleet requirements.

The load factor is defined as the ratio between the number of passengers carried and the available vehicle capacity, expressed as a percentage. Under dynamic operating conditions, the load factor is commonly assumed to be 70%. Feeder vehicle capacity is adjusted to demand characteristics, where small-capacity vehicles (approximately 8 passengers) are typically used to serve residential areas. Vehicle cycle time is calculated as the total round-trip travel time plus dwell times at the origin and destination terminals, expressed as:

$$\mathbf{CT_{ABA} = (T_{AB} + T_{BA}) + (\sigma_{AB}^{\ 2} + \sigma_{BA}^{\ 2}) + (T_{TA} + T_{TB})} \qquad (1)$$

Where T_{AB} and T_{BA} represent one-way travel times, σ_{AB} and σ_{BA} denote travel time deviations, and T_{TA} and T_{TB} are terminal dwell times at the origin and destination, respectively. Terminal dwell time is assumed to be 10% of the one-way travel time. Headway is determined based on vehicle capacity and peak-hour passenger demand using the following equation:

$$\mathbf{H = \frac{60.C.Lf}{P}} \qquad (2)$$

Where C is vehicle capacity, Lf is the load factor, and P is the number of passengers per hour on the most heavily loaded section. The required fleet size is calculated based on the cycle time and headway as follows:

$$\mathbf{K = \frac{CT}{H.fA}} \quad (3)$$

Where *fA* represents the vehicle availability factor, which is assumed to be 100% in this study.

2.4 Vehicle Operating Costs (VOC) and Fare Analysis

Vehicle Operating Costs (VOC) are defined as all economic costs incurred from operating a vehicle under normal conditions for a specific transport service purpose [17]. VOC constitutes a key component in assessing the financial feasibility of feeder transport services and serves as the primary basis for fare determination. In general, VOC consists of fixed costs and variable costs.

Fixed costs are expenses that are independent of vehicle mileage and are primarily time-based. These cost components include vehicle depreciation, capital interest, vehicle taxes, licensing fees (route permits and business licenses), vehicle inspection fees (KIR), and contributions to transport operator associations. Vehicle depreciation is calculated by assuming a residual value of 20% of the initial vehicle purchase price and a depreciation period of seven years [17]. Capital interest costs are calculated using an annual interest rate (i) of 20% and a capital repayment period (n) of 7 years.

Variable costs are costs incurred directly as a result of vehicle operations and are highly influenced by travel distance. The main components of variable costs include fuel costs, driver wages, retribution fees, maintenance and spare parts costs, and overhaul costs. The total annual vehicle operating cost is calculated as the sum of fixed and variable costs:

$$\mathbf{VOC_{TOT}\ /thn = VOC_{T}\ /thn + VOC_{TT}\ /thn} \quad (4)$$

For efficiency analysis and fare setting purposes, VOC is expressed in terms of cost per kilometer:

$$\mathbf{VOC/km = \frac{VOC/thn}{JT/thn}} \quad (5)$$

Where *JT/thn* represents the total annual vehicle mileage. Fare determination for feeder services based on VOC is conducted using two approaches: a payback fare (cost-recovery fare without profit) and a fare with a profit margin. The payback fare is calculated as:

$$\mathbf{Rate_{PB}(Rp/pnp) = \frac{VOC_T/km}{J_{pnp}/km}} \quad (6)$$

Where *Jpnp/km* denotes the average number of passengers per kilometer. A fare with a profit margin is calculated by adding a margin of 15% to the operating cost, in accordance with the guidelines of the Department of Transportation (2003).

2.5 Methods

This study adopts a descriptive–quantitative approach to plan feeder transport services supporting the e-BRT system. The analysis encompasses feeder route and service network planning, operational system analysis, and financial evaluation based on Vehicle Operating Costs (VOC).

The data used in this study consist of primary and secondary data. Primary data were obtained through field surveys covering road network characteristics, travel distances and times, as well as the locations of residential areas and activity centers. Secondary data include land-use information, public transport planning standards, and vehicle operating cost components obtained from relevant government agencies and published literature [14,17].

Feeder route and service network planning was conducted by considering trip generation and attraction, connectivity with e-BRT stations, and service area accessibility. Operational system analysis includes the determination of vehicle capacity, load factor, cycle time, headway, and fleet requirements based on standards issued by the Directorate General of Transportation, with a load factor assumption of 70% [17]. Financial evaluation was carried out through the calculation of VOC per kilometer, which serves as the basis for determining payback fares and fares with an operational margin [17]).

3. RESULTS AND DISCUSSION

3.1 Feeder Route and Service Network Planning

The determination of feeder service lines was based on the results of a stated preference survey, spatial mapping of residential distribution, and a maximum acceptable walking distance of 500 meters. This approach ensured that the proposed feeder routes optimally serve residential areas as well as educational, commercial, and tourism activity centers. The planning process resulted in four feeder service lines serving areas surrounding the Central Parking Station as the main e-BRT hub, namely FD-01 (East), FD-02 (West), FD-03 (South), and FD-04 (North), as detailed in Table 1.

Table 1. Route and Length of Feeder Transport

No	Code	Route Name	Round-trip distance (km)	Route
1	FD-01 (Timur)	Central Parkir – Teuku Umar – PP	16	Halte Central Parkir – Jl. Raya Kuta – Jl. Setia Budi – Jl. Simpang Dewa Ruci – Jl. Sunset Road – Jl. Simpang Dewa Ruci – Jl. Bypass Ngurah Rai – Jl. Raya Pemogan – Jl. Pulau Enggano – Jl. Pulau Bangka – Jl. Pulau Bungin – Jl. Raya Pemogan – Jl. Bypass Ngurah Rai – Jl. Setia Budi – Jl. Raya Kuta – Halte Central Parkir
2	FD-02 (Barat)	Central Parkir – Pantai Kuta – PP	7.3	Halte Central Parkir – Jl. Patih Jelantik – Jl. Raya Legian – Jl. Pantai Kuta – Jl. Melasti – Jl. Sriwijaya – Jl. Patih Jelantik – Jl. Raya Kuta – Halte Central Parkir
3	FD-03 (Selatan)	Central Parkir – Tuban – PP	10.8	Halte Central Parkir – Jl. Patih Jelantik – Jl. Raya Legian – Jl. Pantai Kuta – Jl Raya Kuta – Jl. Blambangan – Jl. Kalianget – Jl. Bakung Sari – Jl. Kartika Plaza – Jl. Kubu Anyar – Jl. Raya Kuta – Jl. Majapahit – Jl. Patih Jelantik – Jl. Raya Kuta – Halte Central Parkir
4	FD-04 (Utara)	Central Parkir – Seminyak – PP	13	Halte Central Parkir – Jl. Patih Jelantik – Jl. Legian – Jl. Raya Seminyak – Jl. Raya Basangkasa –

	Jl. Raya Taman – Jl. Laksamana Basangkasa – Jl. Kayu Aya – Jl. Kayu Jati – Jl. Kayu Aya – Jl. Raya Taman – Jl. Raya Basangkasa – Jl. Raya Seminyak – Jl. Legian – Jl. Sriwijaya – Jl. Patih Jelantik – Jl. Raya Kuta – Halte Central Parkir

Source: Analysis Results (2025)

Based on the survey results, 59.5% of respondents expressed a willingness to shift to feeder transport services. When applied to the existing daily passenger volume at the Central Parking hub (approximately 3,700 passengers per day), this proportion yields an estimated 2,201 potential feeder passengers. The highest passenger demand is observed on FD-01 (East) with 684 passengers, followed by FD-04 (North) with 611 passengers, FD-02 (West) with 462 passengers, and FD-03 (South) with 444 passengers. This distribution indicates that the eastern and northern service areas exhibit higher demand potential, which can be attributed to higher concentrations of residential settlements, commercial areas, and tourism-related activities suggesting the need for greater attention in service frequency planning for these routes.

3.2 Operational System of Feeder Transport Services

The operational system analysis was conducted through the calculation of cycle time, headway, and fleet requirements for each feeder route. Cycle time was estimated based on round-trip travel time, a travel time deviation of 5%, and vehicle dwell time at stops, in accordance with Equation (1). Detailed results are presented in Table 2.

Table 2. Cycle Time Calculation

No	Code	Route Name	Total Stops Travel	Travel Time from A to B (Minutes)	Travel Time from B to A (Minutes)	Circulation Time (Minutes)
1	FD-01 (Timur)	Central Parkir – Teuku Umar – PP	32	30,55	33,25	130,99
2	FD-02 (Barat)	Central Parkir – Pantai Kuta – PP	15	27,28	20,24	81,196
3	FD-03 (Selatan)	Central Parkir – Tuban – PP	22	27,57	27,3	100,814
4	FD-04 (Utara)	Central Parkir – Seminyak – PP	26	34,31	34,15	123,883

Source: Analysis Results (2025)

Based on the calculated cycle times and the target headway range of 5–10 minutes, the required fleet size was determined as 14 vehicles for FD-01, 9 vehicles for FD-02, 11 vehicles for FD-03, and 13 vehicles for FD-04. Under this configuration, all feeder routes achieve an average headway of approximately 9 minutes, ensuring passenger waiting times remain below 10 minutes and comply with public transport service standards. The variation in fleet requirements indicates that routes with higher passenger demand and longer route lengths require higher service frequencies to maintain acceptable operational performance. According to public transport operational guidelines, headways below 10 minutes are considered effective in maintaining service attractiveness and minimizing passenger waiting time. Shorter headways improve service reliability and increase passenger satisfaction, which in turn encourages public transport usage.

3.3 Annual Fleet Mileage

The calculation of annual fleet mileage was conducted under the assumption of 364 operating days per year. The annual travel distance for each vehicle was obtained by multiplying the daily feeder service travel distance by the number of operating days per year. The travel distance includes both the outbound trip starting from the Central Parking Kuta terminal and the return trip back to the same terminal. The resulting annual mileage for each vehicle is presented in Table 3.

Table 3. Annual Travel Distance of the Feeder Transport Fleet

No	Code	Total Travel Distance/year (km/year) Bus (8 seats)
1	FD-01 (Timur)	128/day x 364days = 46.592 km/year
2	FD-02 (Barat)	37/day x 364days = 13.286 km/year
3	FD-03 (Selatan)	76/ day x 364days = 27.518 km/year
4	FD-04 (Utara)	91/day x 364days = 33.124 km/year

Source: Analysis Results (2025)

The analysis results indicate that the total annual mileage of the feeder fleet reaches 120,520 km per year across all routes. FD-01 (East) records the highest mileage, accounting for approximately 39% of the total, followed by FD-04 (North) at approximately 27%, FD-03 (South) at approximately 23%, and FD-02 (West) at approximately 11%. The distribution of annual mileage across the feeder routes therefore reflects differences in both route length and operational intensity, highlighting the importance of balancing route coverage with operational efficiency in feeder transport planning.

3.4 Vehicle Operating Cost (VOC) Analysis

Vehicle Operating Cost (VOC) is defined as all actual economic costs incurred from operating a vehicle under normal conditions for a specific service purpose [17]. In this study, VOC calculations follow the standards issued by the Department of Transportation and are conducted for feeder transport vehicles with a capacity of 8 passengers, the vehicle type is Daihatsu Gran Max Mini Bus (Gran Max MB 1.3 D FH E4) model year 2025, equipped with a 1,300 cc engine and an average fuel consumption of 13.5 km per liter.

The VOC analysis is carried out on an annual basis and consists of fixed and variable cost components (Department of Transportation, 2002). Annual fixed VOC includes vehicle depreciation costs, capital interest costs, and vehicle tax. Based on Law No. 1 of 2022 and Government Regulation No. 35 of 2023, motor vehicle inspection fees (KIR) for mandatory inspected vehicles have been exempted since January 5, 2024. Therefore, route permit fees, vehicle inspection fees, transport association dues, and business licensing fees are assumed to be zero in this study.

Annual variable VOC consists of fuel costs, operational retribution fees, driver wages, spare parts replacement costs, and vehicle overhaul costs. A summary of the calculated fixed and variable Vehicle Operating Costs (VOC) for each feeder route is presented in Table 4. The total annual VOC is obtained by summing the fixed and variable VOC components in accordance with Equation (4). Furthermore, the total VOC per kilometer is calculated using Equation (5) to facilitate the subsequent fare analysis.

Table 4. Annual Vehicle Operating Cost Analysis per Years

Annual Vehicle Operating Cost Analysis per Years

No	Cost Component		Route (Rp)			
			FD-01	**FD-02**	**FD-03**	**FD-04**
Annual Fixed Costs						
1	Vehicle Depreciation Cost		34.527.771			
2	Capital Interest Cost		25.895.829			
3	Vehicle Tax		3.297.000			
4	Other Administrative Costs		143.000			
Total Annual Fixed Costs			63.863.600			
Annual Variable Costs						
1	Fuel Cost		34.512.593	9.841.481	20.384.000	24.536.296
2	Operational Retribution Fees		-	-	-	-
3	Driver Wages		48.000.000	48.000.000	48.000.000	48.000.000
4	Vehicle Washing Cost		12.740.000	12.740.000	12.740.000	12.740.000
5	Spare Parts Replacement Costs					
	a.	Tire Replacement Cost	3.075.072	876.876	1.816.214	2.186.184
	b.	Lubricant (Oil) Replacement Cost				
		Engine Oil	2.205.000	945.000	1.260.000	1.575.000
		Differential (Gear) Oil	356.000	178.000	178.000	178.000
	c.	Filter Replacement Cost				
		Oil Filter	385.000	165.000	220.000	275.000
		Fuel Filter	330.000	165.000	165.000	165.000
		Air Filter	156.000	78.000	78.000	78.000
	d.	Spark Plug Replacement Cost	280.000	140.000	140.000	140.000
	e.	Maintenance (Service) Cost	3.600.000	1.600.000	2.000.000	2.400.000
	f.	Brake Pad Replacement Cost				
		Front Brake Pads (Right/Left)	404.000	202.000	202.000	202.000
		Rear Brake Pads (Right/Left)	370.000	185.000	185.000	185.000

6	Overhaul Costs				
	a. Body Overhaul	6.334.327	1.806.273	3.741.211	4.503.310
	b. Clutch Set Replacement (Gran Max)	380.501	108.502	224.734	270.513
	c. Battery Replacement	349.440	99.645	206.388	248.430
	d. Front Wheel Bearing Replacement	139.776	39.858	82.555	99.372
	e. Rear Wheel Bearing Replacement	85.419	24.358	50.450	60.727
	f. Major Vehicle Service	970.667	276.792	573.300	690.083
Total Annual Variable Costs		114.673.795	77.471.785	92.246.852	98.532.915
Total VOCtot/years		178.537.395	141.335.385	156.110.452	162.396.515
Total VOCtot/km		3.831,18	10.637,92	5.673,95	4.902,16

Source: Analysis Results (2025)

Based on the results presented in Table 4, the annual fixed Vehicle Operating Cost (VOC) is identical across all feeder routes, amounting to Rp 63,863,600 per year, while the annual variable VOC varies according to the operational characteristics of each route. FD-01 records the highest total VOC at Rp 178,537,394, followed by FD-04 at Rp 162,396,516, FD-03 at Rp 156,110,453, and FD-02 as the lowest at Rp 141,335,385. This pattern indicates that routes with longer travel distances and higher operational intensity incur higher total annual operating costs.

However, from an efficiency perspective, FD-01 demonstrates the best performance, with a VOC per kilometer of Rp 3,831.18, whereas FD-02 records a VOC per kilometer of Rp 10,637.92, making it the least efficient route. FD-03 and FD-04 exhibit intermediate efficiency levels, with VOC per kilometer values of Rp 5,673.95 and Rp 4,902.16, respectively. Overall, these results indicate that greater annual travel distances are associated with lower operating costs per kilometer, reflecting the presence of economies of scale in feeder transport operations.

3.5 Passenger Demand and VOC-Based Fare Analysis

The number of passengers per kilometer was calculated based on vehicle capacity, load factor, and route length. Assuming an 8-seat feeder vehicle and a load factor of 70%, the passenger density for FD-01 is estimated at 0.35 passengers/km for a 16 km route. Using the same approach, passenger densities for the other routes are estimated at 0.767 passengers/km for FD-02, 0.519 passengers/km for FD-03, and 0.431 passengers/km for FD-04. These variations reflect differences in route length and potential vehicle occupancy across the respective service corridors.

Subsequently, feeder fare analysis was conducted by converting Vehicle Operating Costs (VOC) into a per-passenger cost, following a cost-based fare-setting approach as recommended by the Department of Transportation (2003) and expressed in Equation (6). Fares were calculated using both a payback fare scheme and a fare with an operational margin, allowing for the estimation of minimum fares required to recover operating costs while ensuring service sustainability. The calculated fares for each feeder route are presented in Table 5.

Table 5. Feeder Transport Fleet Rates per Route

No.	Route	VOC/km (Rp)	J_{PNP}/km	*Payback* Rate ($Rate_{PB}$) (Rp/pnp)	$Rate_{margin+15\%)}$ (Rp/pnp)
1.	FD-01	3.831,18	0,350	10.948,38	11.112,60
2.	FD-02	11.050,28	0,767	13.867,29	14.075,30
3.	FD-03	7.313,21	0,519	10.940,69	11.104,80
4.	FD-04	4.902,16	0,431	11.381,23	11.551,95

Source: Analysis Results (2025)

Based on Table 5, the calculated fares vary across feeder routes in accordance with the Vehicle Operating Cost per kilometer (VOC/km) and the number of passengers per kilometer (JPNP/km). FD-02 records the highest fare at Rp 14,075.30 per passenger, while FD-03 exhibits the lowest fare at Rp 11,104.80 per passenger. These differences are primarily influenced by variations in VOC/km and passenger-carrying capacity across routes.

However, survey results indicate that the majority of respondents prefer fares below Rp 4,000 per passenger. Consequently, government subsidies in the range of approximately Rp 8,000–Rp 11,000 per passenger are required to bridge the gap between cost-based fares and users' willingness to pay. Such subsidy policies are essential to maintain fare affordability for the public while ensuring the operational sustainability of feeder transport services. Moreover, targeted subsidies are expected to increase public transport ridership, reduce reliance on private vehicles, and enhance the overall efficiency of the urban transport system.

4. CONCLUSIONS

Based on the results of the analysis on the planning of feeder transport integrated with the e-BRT system in the Central Parking Kuta area, the following conclusions can be drawn:

1. Feeder Route and Network Design

   The proposed feeder transport system consists of four integrated routes serving the Central Parking Kuta station as the main e-BRT hub:

   a. FD-01 (East) with a round-trip length of approximately 16 km, serving the Dewa Ruci and Bypass Ngurah Rai corridors.

   b. FD-02 (West) with a round-trip length of approximately 7.3 km, connecting Central Parking to the Kuta Beach area.

   c. FD-03 (South) with a round-trip length of approximately 10.8 km, serving the Tuban and Kartika Plaza areas.

   d. FD-04 (North) with a round-trip length of approximately 13 km, connecting the Seminyak and Basangkasa areas.

   All routes are designed to serve residential areas, tourism destinations, and commercial activity centers within a maximum walking distance of 500 meters, thereby supporting first-mile–last-mile connectivity with the e-BRT system.

2. Operational Performance of Feeder Services

   The operational analysis shows that feeder routes have cycle times ranging from 81.20 to 130.99 minutes. Based on these cycle times, the required fleet size is:

   a. 14 vehicles for FD-01

   b. 9 vehicles for FD-02

   c. 11 vehicles for FD-03
   d. 13 vehicles for FD-04

   With this fleet configuration, the feeder system can achieve an average headway of approximately 9 minutes, ensuring acceptable passenger waiting times and meeting urban public transport service standards.

3. Vehicle Operating Costs (VOC)
   The financial analysis indicates that total annual Vehicle Operating Costs range between Rp 141,335,385 and Rp 178,537,394 depending on route characteristics and operational distance.
   a. The lowest operating cost per kilometer is observed on FD-01 at Rp 3,831.18/km, indicating the highest operational efficiency.
   b. The highest operating cost per kilometer occurs on FD-02 at Rp 10,637.92/km, primarily due to shorter operational distance and lower vehicle utilization.
4. Fare Requirements and Subsidy Implication
   The VOC-based fare analysis shows that the required operational fare ranges between Rp 11,551 and Rp 14,075 per passenger to fully recover operating costs. However, public survey results indicate that the preferred fare level is below Rp 4,000 per passenger. Therefore, government subsidies of approximately Rp 8,000–Rp 11,000 per passenger are required to maintain fare affordability while ensuring operational sustainability.
5. Overall Feasibility of the Feeder System
   Overall, the proposed feeder transport system integrated with the e-BRT network is technically feasible, operationally effective, and financially viable with subsidy support. The implementation of this feeder system is expected to improve accessibility to e-BRT services, increase public transport ridership, reduce dependence on private vehicles, and support the development of sustainable urban transportation in the Sarbagita metropolitan area.

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