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The Concept of Calculating Air Transportation Tariffs for Fuel Using the Fuel Aircraft Transportation Tariff Formula for Fuel Distribution to 3T Regions (Underdeveloped, Frontier, and Outermost Areas)

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Fuel Oil Policy; One-Price Fuel; Papua Region; Fuel Distribution; Air Transportation

ABSTRACT
The one-price BBM (Fuel Oil) policy in the Papua region, launched by the Government of Indonesia, represents an effort to realize social justice for all Indonesian people. The government has tasked PT Pertamina with immediately implementing one-price fuel in the Papua region and 3T (Daerah Tertinggal, Terdepan, dan Terluar; Disadvantaged, Frontier, and Outermost) regions. This policy is expected to foster economic growth and development in Papua. However, distributing fuel to remote areas in Papua faces enormous challenges due to limited infrastructure, difficult geographical conditions, extreme weather, and security risks. Air transportation is the only effective mode for fuel distribution to these regions, though it incurs high logistics costs and significant operational complexity. In this study, The Concept of Calculating Air Transportation Tariffs for Fuel Using the Fuel Aircraft Transportation Tariff Formula for Fuel Distribution to 3T Regions (Underdeveloped, Frontier, and Outermost Areas) was developed by integrating a cost-based analysis approach with the Cash-Related Aircraft Operating Cost (CAROC) model, relevant laws and regulations, government policies, Pertamina and Oil and Gas guidelines, and field best practices. This Tariff Formula enables transparent tariff calculations based on key cost components, including aircraft leasing, fuel, maintenance, handling, insurance, and labor. The results provide an objective basis for establishing air transportation tariffs for fuel in areas with limited infrastructure and extreme operational conditions, such as Papua.

INTRODUCTION

The distribution of fuel oil (BBM) to remote areas in Papua faces major challenges, including limited infrastructure, hard-to-reach geographical conditions, extreme weather, and security risks. The air transportation mode is one of the solutions to overcome these access problems (Dahim, 2021; Martín-Domingo et al., 2024; Smirnov et al., 2023; Wensveen, 2023). However, this entails high logistics costs and significant operational complexity (Kementerian ESDM RI, 2016).

Air transportation modes present their own challenges, not only because they are relatively demanding higher operational (logistics) costs, but also because they inherently require stricter rules and regulations to maintain the safety level of flight operations of these air modes, especially for air cargo operations that are the domain of fuel delivery to remote areas.

Fuel is the largest cost component in air operations, and fuel price fluctuations (consequently) exacerbate distribution efficiency challenges (Cullen et al., 2021; Hao et al., 2016; Rolo et al., 2023; Singh & Sharma, 2015). Without a tariff structure based on actual cost analysis, the planning of distribution and procurement of transportation services is prone to inefficiencies and difficult to verify (Brown et al., 2015; Canıtez & Çelebi, 2018).

In this study allows for transparent calculation of rates based on key cost components: fuel, maintenance, insurance, labor, and asset depreciation (Dixon et al., 2017; Mert & Demir, 2016;

Mislick & Nussbaum, 2015). The results of the study are expected to be an objective basis in the preparation of air mode fuel transportation tariffs in areas with limited infrastructure and extreme operational characteristics such as Papua (Lubis, 2024; Toja & Bunahri, 2024).

This study is expected to be an objective and transparent foundation in shaping the distribution realm of fuel shipments to regions/distribution destinations, as well as providing references for compiling fuel transportation tariff structures by air mode, especially in areas in Papua that have various infrastructure limitations and extreme variations in operational characteristics.

The study aims to analyze the main challenges of fuel distribution to remote areas in Papua, particularly focusing on geographical, infrastructure, and extreme risks (Agustus et al., 2025; Aisyah & Sentosa, 2023; Bawan et al., 2025; Fauzi et al., 2023; Sulaeman et al., 2021). Additionally, the study seeks to develop a more objective concept for calculating air mode fuel transportation rates and to determine the cost structure for forming air mode fuel transportation tariffs. The scope of this study encompasses a series of activities, including study, observation, analysis, and modeling, aimed at comprehensively understanding and formulating the structure of fuel transportation tariffs using air modes. This study employs a data-driven approach, considering the technical, cost, and policy aspects of sustainable energy distribution. Specifically, the scope includes the study and observation of the operational pattern of air mode fuel distribution in Papua, the preparation of a systematic fuel distribution process diagram, the mapping of model and distribution cost estimation frameworks, and the review and analysis of cost components and tariff structures.

METHOD

This research employed the Cash Airplane Related Operating Cost (CAROC) methodology to calculate fuel distribution tariffs via air transportation. The CAROC framework ensures objective, transparent, data-driven tariff structures by systematically weighting cost components including fuel and lubricant consumption, crew hours (pilots and technicians), maintenance expenses, landing and navigation fees, aircraft and personnel insurance, administrative overhead, licensing costs, and safety expenditures. All cost components are systematically compiled using structured spreadsheet documentation.

Data collection was carried out through a combination of qualitative and quantitative approaches:

1) **Primary data** was obtained from observations and interviews with stakeholders, especially fuel distribution operators/transporters in Papua.
2) **Secondary data** were collected from industry literature, international references (such as FAA and ICAO), as well as benchmarking of fare structures of similar carriers in typical industrial sectors (air cargo transport) and other remote areas.

The main principles of determining air cargo rates are as follows:

1. Based on actual cost structure

All cost elements are calculated in a transparent and structured manner, in line with existing guidelines (e.g. International Civil Aviation Organization / ICAO) as well as industry praxis benchmark references, which include:

- Aircraft lease/leasing or amortization costs
- Fuel and lubricant consumption
- Crew costs (pilots and technicians)

- Navigation fees and landing fees
- Aircraft maintenance costs
- Ground handling and supporting logistics costs
- Insurance, licensing, and administrative overhead costs

2. Based on Technical Operational Parameters

The calculation of the tariff takes into account the technical variables that affect the efficiency of distribution, including :

- Payload (effective transport capacity in kg/liter)
- Route distance (flight distance)
- Flight time (block hour and flight hour)
- Frequency of transportation (trips per day/month)
- Load factor

3. Calculation Flexibility

Rates can be calculated in several units, depending on the operational scheme, including:

- Rate per flight/trip and Rate per operating hour
- Tariff per Ton-Km, or Tariff per kL-Km
- Rate per kilogram of load, or Rate per liter of fuel

In this study, the approach generally used by transporters is the main parameter of the tariff per liter, based on the calculation of the cost per block hour converted to the actual load volume and also the mission-specific parameter (delivery route).

4. Principles of Data Transparency and Validity

All elements of the fare calculation must be traceable and verifiable. Therefore, the preparation of the tariff model needs to be outlined in the form of a structured working paper (spreadsheet), so that it can be reviewed by stakeholders.

5. Contextualization of Regions and Modes

Pricing must take into account the specific conditions of the route, aircraft type, and destination infrastructure. Routes with extreme terrain, limited frequencies, or low load factors require a different fare approach than flat routes with high volumes.

6. Energy and Subsidy Policy Approach

Tariffs are not only a commercial tool, but also an instrument of public policy. In the distribution of fuel to the 3T region, the tariff that is prepared must support the principles **of subsidy efficiency**, **energy justice**, and **the sustainability of the national distribution program**.

By applying the above principles, air cargo tariffs for fuel distribution can reflect the reality of actual costs on the ground, provide fairness for operators, and maintain the sustainability of energy distribution programs in areas with limited access.

Initial Data Collection

Data collection in this study was carried out through two approaches, namely:

a) Primary Data Collection

The primary data collection in this study was carried out to obtain a comprehensive picture of the fuel distribution process using air modes to remote areas in Papua. Data collection methods include field surveys, direct observations, and interviews with key stakeholders.

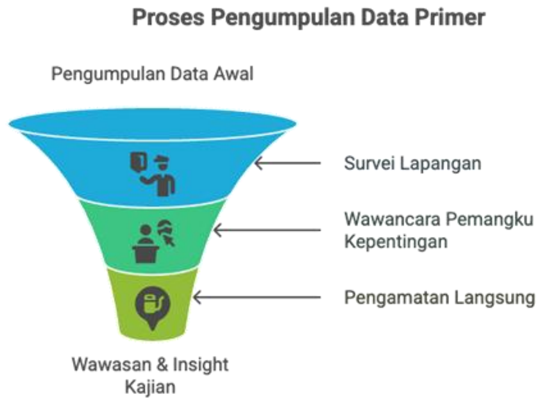


Figure 1. Primary Data Collection Process

- **Field Surveys and Observations**

The implementation team conducted a field visit to the Sentani and Wamena areas, Papua, on January 22-24, 2025, to observe firsthand the operational dynamics of fuel distribution. This activity aims to identify the main factors that affect the effectiveness of distribution, such as:

  - Hard-to-reach geographical conditions
  - Limited transportation infrastructure, including runways and transit warehouses
  - Extreme weather that disrupts flight schedules
  - Availability and capacity of aircraft used

These observations provide an in-depth understanding of field challenges that cannot be identified through secondary data alone.

- **Interview**

Interviews were conducted with various parties directly involved in the air fuel distribution supply chain in Papua. Interviews were conducted with four main transporter operators. The focus of the interview includes:

  - Aircraft operating cost structure and components
  - Aircraft rotation and distribution patterns
  - Procedures for packaging and handling fuel as dangerous goods
  - Technical and non-technical challenges in the field
  - The company's internal policies regarding rates and budgeting

Interviews with the internal VAT unit were also conducted to obtain information related to tariff policies, transporter bill verification systems, and challenges in preparing fuel distribution budgets to 3T regions.

- **Field Findings**

The results of field activities show that there are four main transporters that have a strategic role in distributing fuel to remote areas in Papua. Each has different aircraft types, routes, and capacity characteristics, but overall forms a complementary distribution system.

Information and insights obtained from the field, both through direct observation and in-depth interviews, are an important basis in formulating a realistic and relevant tariff structure. This primary data is also used in the preparation of Owner's Estimate (OE) and in cost modeling using the CAROC framework, so that the results of the study are not only theoretical but also adjust to real conditions in the field.

b) Secondary Data Collection

The study also used secondary data to complete the analysis and ensure the accuracy of the tariff calculation model. Secondary data is collected from a variety of relevant and credible sources, both internal and external, with a focus on the technical, operational, financial, and regulatory aspects of aviation.

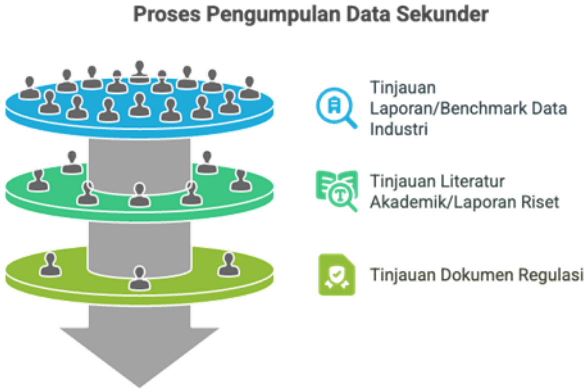


Figure 2. Secondary Data Collection Process

- **Documents from PT Pertamina Patra Niaga (PPN)**

Avtur price data, Owner's Estimate (OE) reports, and details of inter-regional fuel distribution routes in Papua.

- **Technical and financial references**

Taken from trusted sources such as FAA, ICAO, Aircraft Cost Calculator, JetAdvisors, as well as aircraft technical reference documents (e.g. ATR, Cessna Caravan)

- **Aviation industry literature**
  - Guidelines for the transportation of dangerous goods according to IATA regulations
  - Standard operating costs based on aircraft type and operational region
  - Case study of logistics distribution to 3T regions in other developing countries.
- **Aircraft specifications and Technical parameters**

Secondary data also includes technical data on aircraft used by transporters in Papua, including:

  - Payload and payload capacity (liters/kg)
  - Fuel burn rate
  - Maximum maintenance interval and flight hours
  - Average insurance and leasing costs in the market

The data is used to compile the technical parameters in the CAROC model and ensure that the cost calculations reflect operational realities.

RESULTS AND DISCUSSION

The first step in the preparation of a cost-based tariff structure is to identify and analyze the existing tariff structure currently used by operators or transporters in Papua. This process aims to:

- Knowing the cost components that have been used in tariff formation
- Map the calculation schemes applied to different aircraft types, routes, and distribution frequencies
- Identify potential weaknesses, inconsistencies, or untraceability of an existing tariff approach

Based on the data that has been collected and analyzed in the previous stage, the initial preparation of a new tariff scheme is carried out through a calculation model based on CAROC (Cash-related Aircraft Operating Cost). This model began to be tested on a limited scale using various assumptions, technical projections, and data constraints.

The results of this mapping are the basis for a benchmark for the tariff model developed in this study. In addition, the old tariff structure is used as a reference to test the extent to which the new model can improve transparency and accuracy in the verification and budgeting process.

Preparation of Papers

As a crucial stage in the implementation of this study, a Microsoft Excel-based working paper document was prepared to collect operational cost calculations based on field data input and become the basis for analysis and testing of new tariff schemes. The main functions of this paper are:

- As a tool for calculating blocks hour-based fares
- As an instrument for simulating tariff scenarios based on aircraft variations, routes, carrying capacity, and fuel prices
- As a transparent document that can be verified by stakeholders

In the process, this new working paper is compared to existing cost structures (historical OEs) to identify discrepancies, potential waste, and cost efficiency opportunities.

Initial Tariff Simulation Analysis

After the working paper was completed, an initial simulation of the resulting tariff scheme was carried out. The simulation includes several scenarios and assumptions, including:

- Differences in aircraft types and payload capacity
- Route and distance variations between distribution locations
- Indirect costs such as insurance, operational risks, and weather uncertainty
- Utilization rate (load factor) and flight hours per month

This analysis aims to test the resilience of the tariff model to operational conditions on the ground, as well as ensure that the resulting tariffs remain fair and economically viable.

Sourcing Data (Benchmarking)

As an effort to improve the model, the team also benchmarked the standard operating costs of aircraft and airports. This benchmarking is carried out to:

- Determining competitive cost parameters
- Equalizing the estimation base with national and international industry standards
- Identifying deviations from the general standard of cost to the reality in Papua

Benchmarking references are obtained from:

- Transporter operators (contractual data and based on surveys/interviews)
- Aviation industry sources (FAA, ICAO, Aircraft Cost Calculator, etc.)
- Additional fees at airports, especially related to the transportation of dangerous goods.
- Logical justification from the consultant to determine the composition and value of the tariff component in compiling the cost component framework (Cost-Matrix).

With this approach, the developed tariff structure is ensured to be aligned with the field conditions and applicable standards in the industry.

Validation and Finalization

This stage includes final testing, data validation, and final adjustments before the results are officially communicated to stakeholders or used in implementation. Validate the results of the analysis and prepare tariff recommendations that can be implemented.

Steps at this stage include:

- Final review of inputs and assumptions in the working paper
- Logical test of simulation results based on real cases (specific routes)
- Final adjustments to key variables based on survey findings and internal discussions

Evaluation and Improvement

After validation is carried out, the evaluation and refinement process takes place by considering feedback from various parties and final adjustments from the Consultant before the final decision is determined.

This evaluation process is the final step before the model and tariff are finalized in the final report. The final results are expected to be not only technically representative, but also used as a recommendation for the official tariff structure for the distribution of air mode fuel to the 3T region in Papua, as well as can be implemented practically and regularly to support the sustainability of the multi-modal national energy distribution (BBM) program.

Aircraft Type Suitability Analysis for Fuel Distribution

Fuel distribution to remote areas in Papua and North Kalimantan is highly dependent on air modes capable of operating on short runways and extreme geographical conditions. Selecting the right aircraft type is the key to operational efficiency and determining fair fares.

Analysis of the technical specifications of aircraft such as the Cessna 208B, 208-EX, AT802, ATR42-300, and B737-300F is required to assess suitability for airport characteristics, carrying capacity, and cost efficiency. This study supports the calculation of tariffs based on the CAROC model and the optimal fuel distribution strategy in the 3T region.

Specification and Evaluation of Fuel Distribution Aircraft Type

In the distribution of fuel to areas with limited infrastructure, the selection of the right type of aircraft greatly determines the effectiveness and cost efficiency. The following table summarizes the technical specifications of five types of aircraft that are widely used or suitable for use in fuel/fuel distribution missions to non-regular distribution agencies.

Table 1. Technical Specifications of Aircraft Type (from various sources)

Aircraft	MTOW (kg)	Payload Maks (kg)	Mileage (km)	Runway Min (m)	Kargo Volume (m^3)	Engine	Cruising Speed (km/h)	Key Notes
Cessna 208B	±3.995	±1.400	±1.500	740–800	±9.6	Turboprop (1)	280–290	Economical & flexible for small strips
Cessna 208-EX	±3.995	±1.600	±1.600	800–850	±10	Turboprop (1, more powerful)	330–340	Suitable for rough terrain & mountains
AT-802	±7.257	±3.500-3.946	±1.500	500–800	±3.1 (internal)	Turboprop (1)	350-356	Tough on extreme strips, logistics modifications
ATR42-300	±16.700	±5.500–6.000	±1.500	1.050–1.200	±30–40	Twin Turboprop	460-550	Suitable for district airports

B737-300F	±62.800	±18,200	±3.600	±2,200	±109	Twin Jet	780-797	Only for bulk supply to major airports

Evaluation of Aircraft Type Suitability to Airport Infrastructure

From the above specifications, it can be concluded that not all aircraft have the flexibility to reach remote areas. The following table classifies aircraft type suitability based on airport category.

Table 2. Aircraft Suitability to Airport Type

No	Airport/Airstrip	Location	Runway Length	Surface	Facilities	Aircraft Compatibility	Cargo Traffic
1	Sentani International	Jayapura	3,000 m	Asphalt	Full services	B737, ATR42, Cessna 208, AT802	High
2	Wamena Airport	Wamena	2,175 m	Asphalt	Limited	ATR42, Cessna 208, AT802	Medium
3	Moses Kilangin Airport	Timika	2,300 m	Asphalt	Moderate	B737, ATR42, Cessna 208	High
4	Mopah Airport	Merauke	2,500 m	Asphalt	Moderate	B737, ATR42, Cessna 208	Medium
5	Frans Kaisiepo Airport	Biak	3,570 m	Asphalt	Full services	B737, ATR42, Cessna 208	High
6	Nabire Airport	Nabire	1,600 m	Asphalt	Limited	ATR42, Cessna 208, AT802	Low
7	Oksbil Airstrip	Oksbil	800 m	Gravel	Minimal	Cessna 208, AT802	Very Low
8	Dekai Airport	Dekai	1,500 m	Asphalt	Basic	ATR42, Cessna 208	Low
9	Ewer Airstrip	Asmat	700 m	Gravel	Minimal	Cessna 208, AT802	Very Low
10	Kokonao Airstrip	Kokonao	600 m	Gravel	Minimal	Cessna 208, AT802	Very Low
11	Tanah Merah Airport	Tanah Merah	1,200 m	Asphalt	Basic	Cessna 208, AT802	Low
12	Mulia Airstrip	Mulia	500 m	Grass	Minimal	AT802	Very Low
13	Senggeh Airport	Senggeh	1,000 m	Gravel	Basic	Cessna 208, AT802	Low
14	Kaimana Airport	Kaimana	1,600 m	Asphalt	Limited	ATR42, Cessna 208	Medium
15	Fakfak Airport	Fakfak	1,200 m	Asphalt	Basic	Cessna 208, AT802	Low
16	Bintuni Airstrip	Bintuni	800 m	Gravel	Minimal	Cessna 208, AT802	Very Low
17	Wasior Airport	Wasior	1,000 m	Asphalt	Basic	Cessna 208, AT802	Low
18	Sorong Airport	Sorong	2,500 m	Asphalt	Moderate	B737, ATR42, Cessna 208	High
19	Manokwari Airport	Manokwari	2,000 m	Asphalt	Moderate	ATR42, Cessna 208	Medium
20	Boven Digoel Airstrip	Boven Digoel	600 m	Gravel	Minimal	Cessna 208, AT802	Very Low

Tariff Preparation Concept (Modeling and Formulation)

In this study, fuel air freight rates were prepared using a cost-based pricing approach, which is the determination of tariffs based on the calculation of all actual cost components relevant to distribution operations. The goal is to produce a scalable tariff structure that is transparent, and can be applied fairly across different distribution regions, taking into account terrain variations, aircraft modes, and carrying capacity.

The calculation of the fare begins by compiling technical and operational variables as the basis for the simulation, which includes aircraft characteristics, distribution capacity, and direct and indirect cost factors. These cost components are collected through a combination of primary data (interview and survey results) and secondary data from industry references and official documents.

Technical Parameters of the Aircraft

Technical parameters are used to calculate mission efficiency, actual carryability, as well as other operational assumptions in tariff formulation.

a. **Aircraft type**: Determines the transportability, mileage, and technical configuration of the aircraft.
b. **Throughput**: The total maximum payload that the aircraft can carry.
c. **Drum Capacity**: The standard size of the fuel drum used (usually 200 liters).
d. **Maximum Drum Capacity on Aircraft**: The maximum number of drums that can be transported in a single flight.
e. **Drum Weight**: The empty weight of one drum, as an additional factor in calculating the total payload.
f. **Fuel Density**: Required for the conversion of volume (liters) into mass (kilograms), adjusted to the type of fuel.
g. **Aircraft Payload**: The effective carrying capacity for fuel cargo (in kg or liters).
h. **Aircraft Mileage**: The aircraft's capacity to travel a specific route in a single mission without refueling.

Mission Specifications

The mission specification describes the pattern and intensity of fuel distribution in a given period.

a. **Fuel Payload per Trip**: The actual volume of fuel carried in a single flight, minus drum weight and other technical limiting factors.
b. **Payload per Day**: Total daily distribution based on the number of trips and capacity per trip.
c. **Load Factor:** The percentage of aircraft carrying capacity utilization to the maximum capacity (efficiency indicator).
d. **Total Trips per Month**: The frequency of flights per month, based on the distribution plan.
e. **Trips per Day**: The number of flights per day, depending on the route, travel time, and operational conditions.
f. **Route Distance (Flight Distance):** The round-trip distance for a single distribution route.
g. **Flight Hour**: The effective duration of the flight in hours.
h. **Block Hour:** The total time from engine start to engine stop, including takeoff and landing times.

Operational Cost Components

This cost is the basis for calculating fuel air freight rates because it reflects the actual costs incurred during the operational process.

a. **Crew Fees**: These fees include the salaries and allowances of pilots and flight crew on duty on each flight
b. **Fuel Cost**: Fuel costs include the consumption of Avtur or avgas used by the aircraft during the flight.
c. **Ground Handling Fee**: This fee includes aircraft handling services at the airport, such as cargo loading and unloading, aircraft parking, and other support services.
d. **Navigation and Landing Fees**: This component includes air navigation service fees and landing fees at the destination airport.

Maintenance Costs

These costs include activities necessary to maintain the airworthiness and reliability of the aircraft.

a. **Maintenance Burden**: Direct labor costs (mechanics and technicians).
b. **Maintenance Overhead**: Facility costs, administration, and system support.
c. **Routine & Non-Routine Maintenance**: Scheduled and unexpected maintenance costs.
d. **Spare Parts & Materials**: The cost of purchasing parts and consumables.

Fractional Ownership

These fees are used to describe **the allocation of aircraft rental or ownership costs** in the fare.

a. **Fractal Rental/Lease Rate**

This component represents the cost of leasing or leasing aircraft per year allocated for operations. The determination of the charter fee per flight hour is usually based on the total annual charter fee divided by the effective flight hours in a year.

b. **Asuransi/Tarif Sewa (Fractal Insurance/Lease Rate)**

This insurance is important to protect the operator from the risk of financial loss due to accidents or damage to the aircraft during operations, especially in regions with challenging geographical and weather conditions

Administrative & Other Fees

a. **General Overhead Costs:** These costs include general administrative, management, licensing, and office operations expenses that support aviation activities.
b. **System Cost:** Includes expenses for the use of IT systems, navigation, and other operational systems such as monitoring and supporting software.
c. **Operational Coordination (Security) Costs:** This component accommodates additional costs for operational coordination and security aspects, including securing cargo or aircraft at remote airports, coordination with security forces, and special operational contingencies.

Systematic Analysis and Determination of Tariffs

The determination of fuel air freight tariff standardization is carried out through a series of systematic and structured analysis stages. This process starts from the identification of parameters and components that make up the cost; the formulation of an approach to the relationship between cost parameters and operational variables; followed by the preparation of a cost matrix as the basis for data sources (part of the development of mathematical models); and the development of a database of cost variables based on validated and integral scenarios and operating schemes. Then *deliver a* reference for the new tariff "working paper" as a tool in reviewing, evaluating and making decisions related to the existing tariff and its changes.

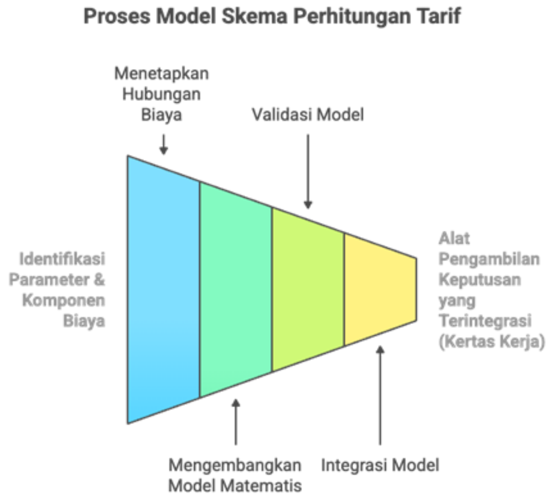


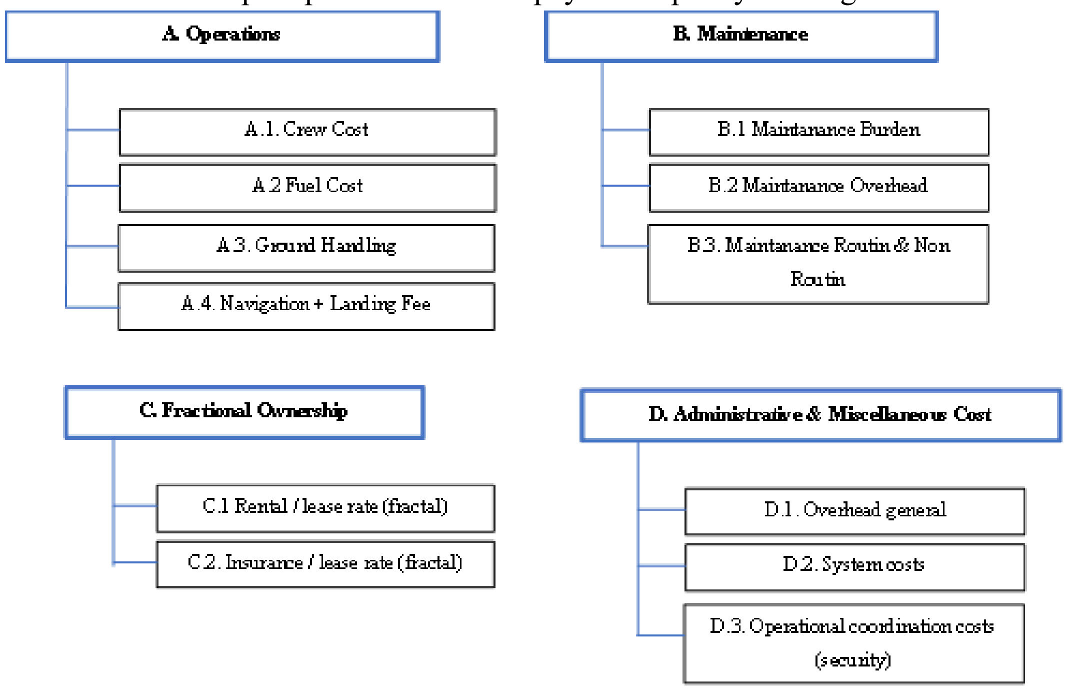
Figure 3. Tariff Calculation Scheme Model Process

Formula Tarif Fuel Aircraft Transportation

The determination of the formula structure of fuel air freight rates is carried out through the Cash Airplane Related Operating Cost (CAROC) approach, which is a cost-based method to determine operational rates objectively and transparently. This approach includes direct costs as a core component in the preparation of the tariff structure:

1. Flight Operation: fuel costs, crew costs, ground handling costs, landing fees, and navigation.
2. Maintenance: routine and unexpected maintenance costs.
3. Ownership (Insurance): insurance and depreciation/depreciation of aircraft assets.
4. Administrative Cost: administrative and managerial support costs.

The component is formulated in the form of Direct Operating Cost (DOC), which is then converted into a rate of Rupiah per liter based on payload capacity and flight mission efficiency.



Basic Calculation Formula:

1. Operational Cost

$$OC = C_{fuel} + C_{crew} + C_{ground\text{-}handling} + C_{landing/parking} + C_{navigation}$$

2. Maintenance Cost

$$MC = C_{burden} + C_{overhead} + C_{routine/non\text{-}routine} + C_{spare\ parts/materials}$$

3. Fractional Ownership Cost

$$FOC = C_{rental\ rate\ (fractal)} + C_{insurance\ rate\ (fractal)}$$

4. Administrative & Misc. Cost

$$AMC = C_{security} + C_{admin\ overhead} + C_{system\ cost}$$

Maka,

$$DOC = OC + MC + FOC + AMC$$

$$\text{Cost per Liter of Payload} = \frac{\text{Direct Operating Cost (DOC)}}{\text{Payload Volume Delivered (liter)}}$$

Conversion Rate:

This formula was further developed into a unit rate in the form of Rp/Liter by referring to the actual payload capacity per mission and fuel transportation efficiency.

In addition to direct costs, there are also indirect costs that also affect the tariff structure but are administrative, general, or risk-based. This indirect cost reflects a cost element that does not occur directly in every flight, but is important to ensure the continuity of operations and management of air transportation service providers.

The indirect cost components of the CAROC approach include:

1. **Cargo Insurance Proportion**
   - The cost of protection against the risk of damage, loss, or accident to fuel loads during the air distribution process.
   - This percentage is usually calculated based on the total value of the payload and the premium standards of the aviation industry.
2. **General Administrative Overhead**
   - Including operational costs of the head office, human resources, finance, legal, information systems, and internal supervision.
   - Although not tied to a specific route or mission, these costs are still charged proportionately to the entire fleet and operations.
3. **System Cost**
   - Development costs, maintenance of fleet management systems, operational reporting, and route or load monitoring technology.
   - It also includes the integration of an integrated logistics system between the transporter and the authority/client.
4. **Contingency/Profit Margin**
   - It is used to cover operational fluctuations such as inclement weather, sudden maintenance costs, or fuel price variability.
   - This component is also the basis for adding a reasonable profit margin to the tariff structure.

Although indirect *costs* are not always included in the main DOC calculations, in this approach to the study, indirect costs are still accounted for in a structured and proportional manner, and are described as part of the final component of the tariff.

Preparation of the Cost Matrix

This stage is an important process in compiling the operational cost structure of air modes, by bringing together various sources of information to form an accurate and verifiable cost matrix.

The preparation of the cost matrix is carried out by:

- Compile data from operators, regulators, and industry references (AviaCost, FAA, JetAdvisors, etc.)
- Groups cost data by category: rent, fuel, labor, maintenance, etc.
- Adjust the cost structure to the geographical conditions and operational characteristics of the Papua region.

The final result of this stage is a cost matrix per component that is the basis for the development of the tariff model. This cost matrix is not only a calculation tool (database), but also plays a role as the main input in the construction of a cost variable database and as the main reference in the preparation of tariff working papers. The resulting cost matrix structure ensures that each cost element is accounted for transparently and in accordance with applicable industry practices.

COST MATRIX (HOURLY, IN USD)

Aircraft	A. Operational Costs				B. Maintenance Costs				C. Fractional Ownership Costs		D. Administrative & Miscellaneous Costs		
Category	Crew Cost	Fuel Consumption Cost	Ground Handling Cost	Landing and Navigation Fee	Maintenance Burden	Maintenance Overhead	Routine & Non-Routine Maintenance	Spare Parts & Materials	Aircraft Rental Rate	Aircraft Leasing Rate	General Administration Overhead	System Cost	Biaya koordinasi operasional (keamanan)
AT802	$310,00	$330,00	$80,00	$3,38	$118,00	$80,00	$606,00	$100,00	$630,40	$188,00	$183,61	$77,40	$853,81
Cessna 208B	$245,00	$140,00	$40,00	$2,11	$157,00	$55,00	$555,00	$45,00	$304,40	$86,60	$124,25	$49,70	$434,25
Cessna 208-EX	$367,00	$143,00	$40,00	$2,11	$187,00	$88,00	$573,00	$82,00	$340,40	$88,00	$131,13	$83,48	$463,13
ATR42-300	$201,00	$237,00	$120,00	$9,38	$189,00	$88,52	$672,88	$29,00	$2.493,76	$496,75	$318,57	$125,43	$582,89
B737-300F	$1.546,79	$3.658,00	$1.600,00	$44,17	$188,28	$86,78	$677,00	$412,00	$4.493,66	$888,73	$883,48	$383,38	$2.588,03

COST MATRIX (MONTHLY, IN IDR)

Aircraft	A. Operational Costs				B. Maintenance Costs				C. Fractional Ownership Costs		D. Administrative & Miscellaneous Costs		
Category	Crew Cost	Fuel Consumption Cost	Ground Handling Cost	Landing and Navigation Fee	Maintenance Burden	Maintenance Overhead	Routine & Non-Routine Maintenance	Spare Parts & Materials	Aircraft Rental Rate	Aircraft Leasing Rate	General Administration Overhead	System Cost	Biaya koordinasi operasional (keamanan)
AT802	Rp82.458.000,00	Rp88.628.000,00	Rp10.080.000,00	Rp777.231,00	Rp28.184.800,00	Rp18.128.480,00	Rp128.988.000,00	Rp20.160.000,00	Rp167.328.000,00	Rp33.456.880,00	$35.017.288,48	$15.604.519,39	Rp117.836.298,48
Cessna 208B	Rp114.464.000,00	Rp65.403.000,00	Rp18.688.000,00	Rp986.254,00	Rp73.350.400,00	Rp30.368.480,00	Rp259.288.000,00	Rp21.024.000,00	Rp142.028.608,00	Rp25.405.760,00	$56.045.004,52	$23.219.601,78	Rp202.661.604,32
Cessna 208-EX	Rp124.742.400,00	Rp99.809.800,00	Rp18.688.000,00	Rp985.254,00	Rp73.350.400,00	Rp30.368.480,00	Rp267.705.604,00	Rp24.294.400,00	Rp158.848.000,00	Rp31.769.800,00	$61.283.348,32	$24.505.338,18	Rp218.273.749,32
ATR42-300	Rp98.460.000,00	Rp224.489.400,00	Rp118.884.000,00	Rp8.359.528,00	Rp179.028.800,00	Rp84.712.784,00	Rp542.442.496,00	Rp28.521.600,00	Rp2.362.080.000,00	Rp472.419.800,00	$289.501.481,80	$115.800.568,64	Rp450.694.105,80
B737-300F	Rp741.948.333,33	Rp1.109.472.000,00	Rp488.000.000,00	Rp13.780.148,00	Rp84.767.780,00	Rp17.718.480,00	Rp148.024.000,00	Rp128.844.000,00	Rp1.402.818.800,00	Rp280.403.760,00	$327.822.861,71	$131.048.188,68	Rp1.067.303.886,04

COST MATRIX (ANNUALLY, IN IDR)

Aircraft	A. Operational Costs				B. Maintenance Costs				C. Fractional Ownership Costs		D. Administrative & Miscellaneous Costs		
Category	Crew Cost	Fuel Consumption Cost	Ground Handling Cost	Landing and Navigation Fee	Maintenance Burden	Maintenance Overhead	Routine & Non-Routine Maintenance	Spare Parts & Materials	Aircraft Rental Rate	Aircraft Leasing Rate	General Administration Overhead	System Cost	Biaya koordinasi operasional (keamanan)
AT802	Rp749.862.000,00	Rp798.338.000,00	Rp120.960.000,00	Rp8.328.772,00	Rp278.208.000,00	Rp198.536.800,00	Rp1.461.628.000,00	Rp241.920.000,00	Rp2.007.938.880,00	Rp401.687.200,00	$466.135.681,78	$187.254.232,79	Rp1.411.823.581,78
Cessna 208B	Rp1.373.568.000,00	Rp784.896.000,00	Rp224.256.000,00	Rp11.824.248,00	Rp830.204.800,00	Rp364.415.800,00	Rp3.111.852.000,00	Rp252.288.000,00	Rp1.704.348.660,00	Rp340.869.120,00	$656.365.051,64	$278.635.220,74	Rp2.434.872.051,84
Cessna 208-EX	Rp1.496.908.800,00	Rp801.715.200,00	Rp224.256.000,00	Rp11.824.248,00	Rp830.204.800,00	Rp364.416.800,00	Rp3.212.467.200,00	Rp291.532.800,00	Rp1.906.176.000,00	Rp381.235.200,00	$735.182.083,84	$294.064.083,54	Rp2.589.484.883,84
ATR42-300	Rp1.167.760.000,00	Rp2.693.836.800,00	Rp1.383.368.000,00	Rp112.314.240,00	Rp2.148.243.580,00	Rp775.882.440,00	Rp6.509.309.952,00	Rp318.288.240,00	Rp28.344.960.000,00	Rp5.666.382.000,00	$3.474.016.619,20	$1.389.608.727,66	Rp5.408.329.267,20
B737-300F	Rp8.903.584.000,00	Rp13.313.664.000,00	Rp5.916.000.000,00	Rp165.361.716,00	Rp405.313.120,00	Rp212.584.320,00	Rp2.168.288.000,00	Rp1.542.528.000,00	Rp16.824.225.600,00	Rp3.364.845.120,00	$3.931.475.906,48	$1.572.590.380,19	Rp13.047.644.220,48

Figure 3. Table Cost Matrix

Construction of Cost Variable Databases

After compiling the cost matrix, the next step is to build a database of cost variables that serves as the main foundation in calculating fuel transportation rates through air modes.

A database of cost variables is compiled based on actual data that has been classified in measurable and relevant units, such as:

- Fuel burn rate (liter per jam)
- Crew and aircraft flight hours per month
- Aircraft maintenance intervals
- Frequency of distribution per month

This database is designed so that each variable has a quantitative form that can be incorporated directly into the calculation model. For example, fuel costs are calculated based on the price per liter multiplied by the aircraft's average hourly consumption; labor costs are calculated from salaries per month divided by average operating hours; and maintenance is quantified from the use cycle data of aircraft components.

Analisis Struktur Biaya CAROC Kargo Udara BBM

Karakteristik	Deskripsi	Faktor	Contoh
Konsumsi Bahan Bakar	Biaya bahan bakar yang dikonsumsi selama transportasi.	Jenis pesawat, jarak, muatan, kondisi penerbangan.	Pesawat yang lebih besar mengonsumsi lebih banyak bahan bakar tetapi menawarkan ekonomi skala.
Gaji Awak	Gaji dan tunjangan bagi awak pesawat dan staf darat.	Ukuran kru, tingkat pengalaman, jam operasional.	Penerbangan jarak jauh memerlukan lebih banyak kru dan pilot bersertifikat.
Biaya Pemeliharaan	Pemeliharaan rutin dan perbaikan untuk pesawat.	Jenis pesawat, kondisi operasional, jadwal pemeliharaan.	Pesawat yang lebih tua memerlukan pemeliharaan yang lebih sering.
Biaya Asuransi	Premi untuk asuransi pesawat dan kargo.	Jenis pesawat, jenis kargo, tingkat risiko operasional.	Mengangkut bahan berbahaya meningkatkan premi asuransi.
Biaya Pendaratan & Navigasi	Biaya yang dikenakan oleh otoritas bandara dan penyedia navigasi.	Lokasi bandara, ukuran pesawat, frekuensi penerbangan.	Bandara terpencil mungkin mengenakan biaya pendaratan yang lebih tinggi.
Kepatuhan Regulasi	Biaya terkait inspeksi keselamatan dan dokumentasi.	Kompleksitas regulasi, frekuensi audit.	Standar keselamatan internasional memerlukan pelatihan khusus.
Biaya Overhead	Biaya administrasi dan biaya tidak langsung.	Skala operasi, struktur organisasi, praktik manajemen.	Beragam berdasarkan skala dan struktur operasional.

Figure 4. Analysis of the CAROC Fuel Air Cargo Cost Structure

All variables in this database are then tested for sensitivity to price changes and other operational parameters. This includes simulations of fluctuations in avtur prices, changes in mission duration or distance, to extreme operational scenarios such as bad weather or suboptimal cargo loads. This sensitivity test aims to ensure that the resulting tariff scheme is not only accurate under normal conditions, but also resilient to the dynamics and risks common in the field, particularly in fuel distribution operations in remote areas.

Sensitivity Analysis and Tariff Simulation

At this stage, a sensitivity analysis and tariff simulation were carried out to test the resilience of the tariff model to various changes in operational conditions and cost variables. This test uses scenarios compiled based on variations in fuel prices (avtur), fleet utilization rates, and operational profile characteristics in regions with diverse geographical and environmental conditions, such as extreme weather differences, hard-to-reach terrain, and limited infrastructure access.

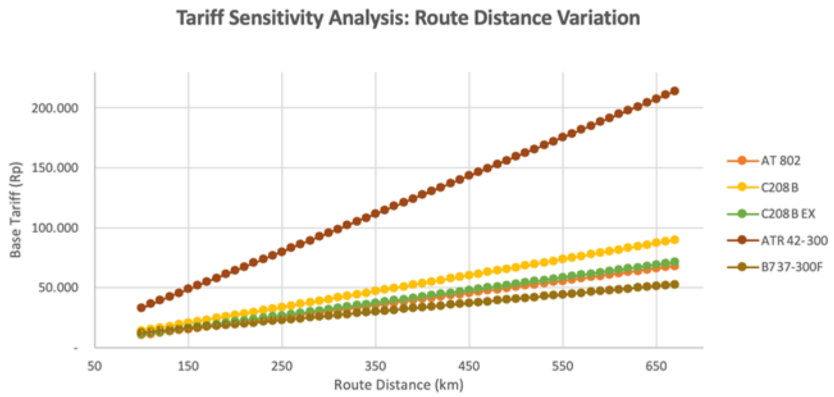


Figure 5. Tariff Sensitivity Analysis: Route Distance Variation

Each scenario is designed to represent possible real conditions in the field that could affect the efficiency and cost of transporting fuel using air modes. For example, the scenario of an increase in avtur prices by up to 20%, a decrease in monthly flight hours due to weather factors, or an increase in operational costs in areas with minimal runways and limited navigation facilities.

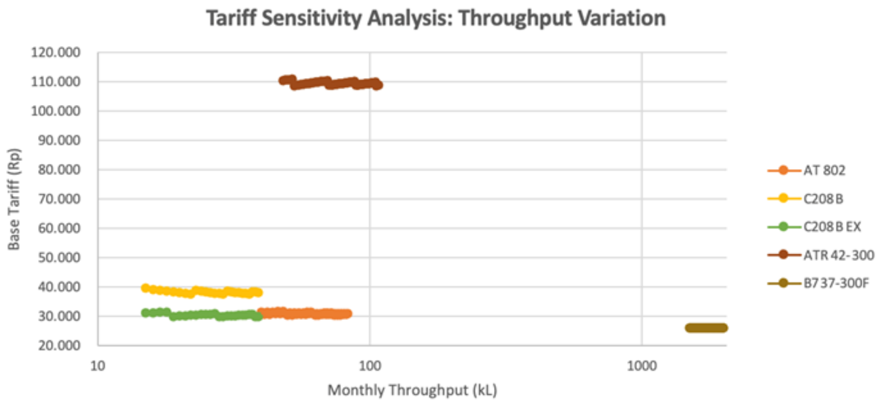


Figure 6. Tariff Sensitivity Analysis: Throughtput Variation

By conducting simulations based on these various scenarios, the team was able to identify the most critical variables that had the most influence on the final tariff, as well as determine the tolerance limits for changes that were still acceptable in the tariff structure. In addition, this simulation provides a rational basis for designing a cost buffer or tariff adjustment component to ensure the sustainability of distribution services, particularly in the context of operations in 3T areas (disadvantaged, frontier, and outermost).

The results of this sensitivity analysis are then an important reference in finalizing tariff working papers, as well as in the preparation of tariff policy recommendations that are more adaptive and resistant to market dynamics and operational challenges in the field.

Preparation of Tariff Worksheet (Excel-Based Worksheet)

As a final stage, a tariff worksheet based on Microsoft Excel was prepared as the main tool for tariff calculation. The model includes dynamic formulas and input parameters, and can be used to simulate the fares of different aircraft types and operating areas. This working paper is designed with a modular structure and dynamic formula, allowing users to enter various input parameters such as aircraft type, carrying capacity, route, fuel consumption, avtur price, as well as fixed cost variables and other variables.

The model supports calculation scenarios for different aircraft types and operating area conditions, including simulations of sensitivity to price changes or fleet utilization. The worksheet is equipped with a display that makes it easy to analyze, as well as an output section that automatically displays the estimated unit rate based on the inputs entered.

In addition to being a calculation tool, this worksheet is also compiled to support the validation and transparency process in tariff preparation. Technical instructions for filling in the data and parameters are provided separately, to ensure consistency of use and accuracy of the results generated from the model. In general, this working paper is designed not only as a tariff calculation tool, but also as a platform to support strategic decisions, especially in:

- Preparation of an accurate and accountable Owner's Estimate (OE)
- Verification of the bill from the transporter, through comparison against estimates based on the actual cost model
- The basis for contract negotiations and fuel subsidy policies, with an objective, adaptive tariff approach, and in accordance with the principles of national energy distribution efficiency.

Results of Modeling, Construction, and Calculation of Tariff Schemes

Based on data that has been compiled from various data, systematically analyzed, and included in the working paper, a fuel air freight tariff scheme was prepared that reflects the actual operational conditions in the field. This tariff scheme is designed to provide a realistic, fair, and transparent picture of costs for all parties involved in the fuel distribution chain, especially in areas with high geographical challenges such as Papua.

The tariff is calculated in units per liter and/or per kilogram, depending on the distribution scheme and the form of transportation used (drum, IBC tank, or bulk system).

The tariff calculation formula combines two main groups of cost components, namely:

- Direct costs:

  Including fuel costs, crew costs, aircraft rental/leasing, routine and non-routine maintenance, navigation and landing costs, and ground handling services.
- Indirect costs:

  This includes administrative overhead costs, aircraft and cargo insurance, logistics and reporting systems, and risk margins (contingency) required to deal with operational dynamics such as extreme weather, logistics disruptions, or fluctuations in avtur prices.

With a CAROC-based approach and adaptive paperwork, the fare scheme also allows for simulation and rapid adjustment in the event of changes to key variables, such as fuel prices, aircraft utilization, or actual freight loads. This makes the tariff structure not only relevant today, but also sustainable and responsive to future operational challenges.

Figure 8. Comparison of Hourly Operating Costs by Aircraft Type

The graph above shows that larger capacity aircraft, such as the Boeing 737-300F, have the highest hourly operating costs compared to other aircraft. However, the high cost is proportional to its much larger carrying capacity, so on routes with high distribution volumes, this type of aircraft has the potential to provide better cost efficiency per liter than small capacity aircraft such as the Cessna 208B.

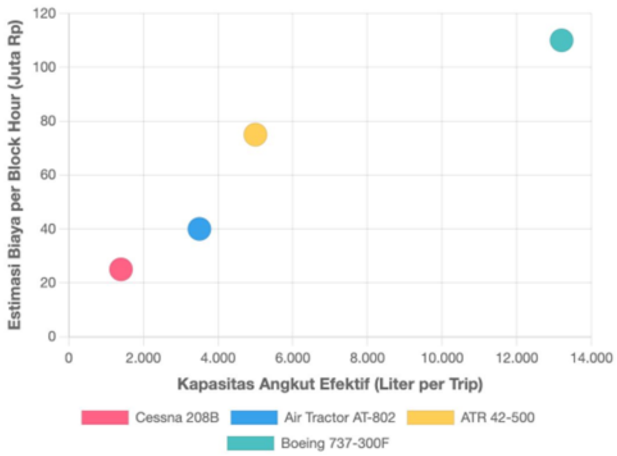


Figure 9. Comparison of Estimated Operating Costs per Block Hour and Effective Carrying Capacity per Trip

To support the quantitative analysis, the graph above shows the estimated cost per block hour to the effective carrying capacity for the various types of aircraft studied. The higher the carrying capacity, the block hour cost tends to increase, but the cost efficiency per liter can improve depending on the operational scenario and utilization rate.

CONCLUSION

The analysis using the Fuel Aircraft Multimodal Transportation Formula shows that air-mode fuel distribution tariffs in Papua can be calculated objectively, accurately, and efficiently when all cost components—such as flying mission parameters (distance and route conditions), load efficiency, and aircraft operational factors like fuel consumption—are properly identified, inputted, and validated. It underscores the complexity of rate determination, involving multi-variable technical and non-technical influences, with costs varying by aircraft type, payload, mileage, and regional zoning differences. Sensitivity analysis reveals significant impacts, such as a 15% load factor drop raising tariffs by 44-63% and a 20% avtur price increase lifting logistics rates by 8-9%, highlighting the need for supply-demand management, load optimization, and favorable operator contracts. For future research, exploring advanced machine learning models to dynamically predict and mitigate these cost sensitivities in real-time, incorporating climate and geopolitical variables, could further enhance tariff precision and scalability across Indonesia's remote regions.

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