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A Techno-Economic Framework for Natural Gas Pipeline Tariff Determination Under State Budget Financing:Evidence from The Semarang-Batang Open-Access Transmission Pipeline, Indonesia

Aji Agraning Bawono[1] and Sutrasno Kartohardjono[2]

[1]Regulatory Agency for Downstream Oil and Gas (BPH Migas),
Kapten Tendean Street No. 28, Mampang Prapatan, South Jakarta, Special Capital Region of Jakarta, Indonesia.
[2]Department of Chemical Engineering, Faculty of Engineering, Universitas Indonesia,
UI Campus, Depok, West Java 16424, Indonesia.

Corresponding author: Aji Agraning Bawono (aji.bawono@esdm.go.id)

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ABSTRACT - Natural gas pipeline tariff regulation in Indonesia has historically been designed for investor -financed infrastructure, where tariffs must recover capital costs at a commercially determined weighted average cost of capital (WACC). The Semarang-Batang Transmission Pipeline (Cisem Phase I), the first open-access transmission pipeline in Indonesia constructed under State Budget (APBN) financing,demands a fundamentally different tariff framework. This study develops and evaluates two alternative tariff formulation models tailored to government-funded infrastructure: (i) the State Capital Participation (PMN) scheme, which recovers capital at the government's retail sukuk coupon rate (IRR = 3.97%), and (ii) the State Property (BMN) scheme, which waives capital recovery entirely and charges only a management fee (CAPEX = 0). Results show that the BMN scheme delivers the lowest tariff of USD 0.279/MSCF, representing 55.7% below the conventional WACC-based tariff (USD 0.630/MSCF) and 25.0% below the PMN scheme (USD 0.372/MSCF). Sensitivity analysis confirms the BMN scheme's structural advantage: it eliminates IRR-driven tariff volatility and maximizes affordability for industrial end-users. These findings provide a replicable techno-economic framework and a practical policy basis for BPH Migas in determining transportation tariffs for APBN-financed pipeline infrastructure across Indonesia.

Keywords: natural gas pipeline tariff; APBN financing, state capital participation (PMN), state property (BMN), cost-of-service regulation, techno-economic analysis

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INTRODUCTION

Natural gas is widely considered a critical transition fuel in Indonesia's long-term energy strategy. It offers lower carbon intensity than coal and oil while supporting industrial competitiveness and household energy access. Since the early 2000s, the Government of Indonesia has pursued the development of a Trans-Java gas transmission backbone, envisioning an integrated pipeline network linking upstream production centers in East Java and Kalimantan with demand centers in Central and West Java. This network was originally conceived as three interconnected segments: the Kalimantan-Java Pipeline (Kalija), the Gresik-Semarang Pipeline (Gresem), and the Cirebon-Semarang Pipeline (Cisem). All three were tendered by BPH Migas through competitive bidding beginning in 2006 (BPH Migas 2013; Purwanto & Sommeng 2013; IGU 2022; Widarsono 2007; Winarsih 2022)

The Cisem pipeline, intended to complete the Trans-Java backbone, encountered a fundamental economic barrier. At the end of 2020, the private-sector concession holder returned the project to the government, determining that the pipeline was not commercially viable under conventional investor-financed tariff structures. This episode illustrates a well-documented regulatory dilemma in public utility economics: infrastructure functioning as a natural monopoly must balance investor return requirements with the need for affordable downstream tariffs (Brigham & Pettway 1973; Hunt 2014; Tapia 2010). When private-sector WACC requirements make tariffs unaffordable, demand fails to materialize, undermining project feasibility in a self-reinforcing cycle (Weijermars 2011).

In response, the government commissioned BPH Migas in 2021–2022 to conduct a feasibility study for constructing the Cisem pipeline using State Budget (APBN) financing. Instead of recovering private capital at WACC, the tariff may be calculated either under a State Capital Participation (PMN) framework (recovering investment at the government's low cost of capital) or a State Property (BMN) framework, in which no capital recovery is sought, and the pipeline is operated as public infrastructure for a management fee only (ESDM 2021; Universitas Indonesia & BPH Migas 2022).

The academic literature on pipeline tariff regulation overwhelmingly addresses investor-financed infrastructure. Siswanto (2011) established the foundational cost-of-service model for Indonesian monopoly transmission pipelines, which forms the basis of BPH Migas Regulation No. 38/2023 and BPH Migas Regulation No. 30/2024 (BPH Migas 2024). International frameworks such as FERC (1999) and Hunt (2014) address WACC-based rate-of-return regulation for regulated utilities. Damodaran (2012, 2015) provides methodologies for estimating equity risk premia and country risk premiums applicable to emerging-market infrastructure. However, none of these frameworks address tariff formulation for government-owned, APBN -financed open-access pipelines (NERA Economic Consulting 2017; Utomo & Dianita 2025; BPH Migas 2024; Naumoski 2011)

This study fills that gap by developing, applying, and comparing two tariff formulation models for APBN-financed open-access pipeline infrastructure. Three specific objectives guide the research: (1) to formulate tariff calculation models under PMN and BMN schemes; (2) to evaluate and compare resulting tariff levels against techno-economic principles, engineering professional standards, and K3L requirements; and (3) to provide evidence-based policy recommendations to BPH Migas. The findings are directly applicable to Cisem Phase II and other planned government-financed pipeline segments across Indonesia (ESDM 2024; BPH Migas 2026).

METHODOLOGY

Study object and scope

The Semarang-Batang Transmission Pipeline (Cisem Phase I) is a 60-km open-access gas transmission pipeline with an entry point in Semarang and an exit point at the Batang Integrated Industrial Zone (KITB), Central Java Province. It achieved mechanical completion in 2023, with commercial gas-in operations commencing in December 2023 (ESDM 2024). A quantitative techno-economic analysis methodology is applied, drawing on primary data from BPH Migas regulatory documents and the joint BPH Migas-Universitas Indonesia feasibility study (2022), supplemented by secondary data from peer-reviewed literature.

Conventional tariff baseline

The conventional cost-of-service tariff framework (BPH Migas 2019; FERC 1999) is established as the reference baseline in Equation 1 through 3

$$Tariff = \frac{Cost\ of\ Service}{Gas\ Volume} \tag{1}$$

$$Cost\ of\ Service = (CAPEX \times CRF) + O\&M + Levy + Tax + Return \tag{2}$$

$$WACC = \left(\frac{E}{V} \times Re\right) + \left(\frac{D}{V} \times Rd \times (1-t)\right) \tag{3}$$

where *Tariff*, *Cost of Service*, Annual *Gas Volume*, *Capex*, *CRF*, *O&M*, *Levy*, *Tax*, *Return*, *WACC*, $\frac{E}{V}, \frac{D}{V}$, R_e, Rd, and t are the natural gas transmission tariff (USD/MSCF), the total annual cost of service (USD/year), the annual transported gas volume (MSCF/year), the capital expenditure (USD), the capital recovery factor (dimensionless), the annual operation and maintenance cost (USD/year), the annual BPH Migas *levy* (USD/year), the annual corporate tax expense (USD/year), the allowable annual return on invested capital (USD/year), the weighted average cost of capital (%), the equity fraction of total capital (dimensionless), the debt fraction of total capital (dimensionless), the cost of equity (%), the pre-tax cost of debt (%), and is the corporate tax rate, respectively. Applying these parameters to Cisem Phase I yields a WACC and IRR of 11.77% and a conventional *Tariff* of USD 0.630/MSCF. (Annin & Falaschetti 2008; Damodaran 2017).

PMN scheme: state capital participation

Under the PMN scheme, the allowable return is capped at the retail sukuk coupon rate (3.97% as of 2022) rather than the private-sector WACC (U.S. Department of the Treasury 2022), as shown in Equation 4.

$$\boldsymbol{Tarif\ PMN} = \frac{[(CAPEX \times CRF_{PMN}) + O\&M + Levy + Tax]}{Gas\ Volume} \tag{4}$$

where $Tariff_{PMN}$, CRF_{PMN}, and *Volume* are the transmission tariff under the state capital participation scheme (USD/MSCF), the capital recovery factor calculated using the PMN financing rate (dimensionless), and the annual transported gas volume used in the tariff calculation (MSCF/year), respectively.

BMN scheme: state property

Under the BMN scheme, CAPEX = 0. The tariff consists solely of an operating cost recovery component plus a BLU management fee in Equation 5.

$$Tariff\ BMN = \frac{[110\% \times (O\&M + Levy + Tax + BLU\ Service\ Fee)]}{Gas\ Volume} \tag{5}$$

where $Tariff_{BMN}$ is the transmission tariff under the state property scheme (USD/MSCF) and BLU Service Fee is the annual management fee charged by the public service agency operator (USD/year), respectively.

Input data and sensitivity analysis

All input parameters, total project CAPEX, projected annual O&M costs, gas throughput volume (MMSCFD), pipeline technical life (30 years), regulatory levy rates, applicable tax rates, and government sukuk coupon rates were sourced from the official BPH Migas-Universitas Indonesia feasibility study (2022). Sensitivity analysis examines three variables: (1) IRR/coupon rate, (2) annual gas throughput volume, and (3) equity/debt proportion.

RESULT AND DISCUSSION

Comparative tariff results

Table 1 summarizes the tariff simulation results for the three calculation schemes. The results reveal a substantial and systematic reduction in tariffs as capital recovery obligations are progressively reduced.

Figure 1 presents a visual comparison of tariff results. The BMN scheme achieves the largest reduction at USD 0.279/MSCF (55.7% below baseline), while the PMN scheme achieves a 41.0% reduction at USD 0.372/MSCF.

The BMN Scheme: Economic Justification

The BMN scheme's tariff superiority stems from the complete elimination of CAPEX from the cost-recovery Equation (Equation 5). The government does not operate national backbone infrastructure with a commercial profit motive; rather, the objective is to maximize public utility, enabling affordable gas access for industrial consumers and generating returns through tax revenues, regulatory levies, and BLU management fees (Purwanto & Sommeng 2013; Brigham & Pettway 2009).

Figure 2 illustrates the COS breakdown. In the conventional scheme, CAPEX recovery accounts for 63.7% of total annual COS, while in the BMN scheme, this component is eliminated entirely.

Figure 2. Annual COS breakdown by scheme, Cisem Phase I (USD Million/year). This illustrates the annual cost-of-service (COS) breakdown under the conventional, PMN, and BMN schemes for Cisem Phase I (USD million/year). The figure shows that CAPEX recovery dominates the conventional scheme, whereas the BMN scheme eliminates CAPEX recovery and retains only O&M, levy, tax, and BLU management fee components.

The downstream demand stimulus effect is equally important. As demonstrated by Utomo and Dianita (2025), gas selling price is the dominant determinant of economic feasibility in city gas distribution projects in Indonesia. By reducing the upstream transmission tariff, the BMN scheme creates conditions favorable for private investment in downstream distribution networks, extending the multiplier effect beyond heavy industry to the broader population along the pipeline corridor.

Policy implications: PMN vs. BMN selection

While the BMN scheme consistently produces lower tariffs, the PMN scheme retains policy relevance where: (i) fiscal accounting requires explicit attribution of capital returns; (ii) the government anticipates future privatization of the pipeline asset; or (iii) the regulatory framework mandates capital recovery for all APBN-financed infrastructure (Damodaran 2015; NERA Economic

Tabel 1. Tariff simulation results: conventional, PMN, and BMN schemes, Cisem phase I

No.	Scheme	Key parameter	Tariff (USD/MSCF)	vs Conv.
1	Conventional	IRR = WACC = 11.77% Equity 30% / Debt 70%	0.630	,
2	PMN Scheme	IRR = 3.97% (Retail Sukuk)	0.372	−41.0%
3	BMN Scheme	CAPEX = 0 Mgmt Fee + BLU	0.279	−55.7%

Consulting 2017). BMN is optimal when the primary policy objective is to maximize downstream affordability, the precise objective that motivated the government's takeover of the Cisem project. BPH Migas should formalize PMN/BMN selection criteria within its tariff regulations, providing transparent decision rules for future APBN-financed pipelines. The framework developed in this study provides a replicable template for Cisem Phase II and other planned government-funded pipeline segments (Brigham & Pettway 1973; FERC 1999; Hunt 2014).

Table 2. Key economic input parameters, Cisem Phase I

No.	Parameter	Symbol	Value
1	Total CAPEX	CAPEX	USD 82,521,846
2	Technical Life	d	30 years
3	Annual O&M (3.5% CAPEX)	O&M	USD 2,888,265/yr
4	Risk-Free Rate (avg 2017–21)	Rf	1.94%
5	Base Premium ME (avg 2017–21)	BPMEM	5.33%
6	Indonesia Country Risk Prem.	ICRP	2.41%
7	Beta β (PGAS vs JKSE)	β	1.27
8	Cost of Equity	CoE	11.77%
9	Corporate Tax (UU 7/2021)	T	22%
10	WACC (100% equity)	WACC	11.77%
11	Sukuk Coupon Rate (avg 2022)	IRR_PMN	3.97%
12	Gas Throughput (base)	Vol	33.42 MMSCFD
13	BPH Migas Levy	Levy	2.5% rev.

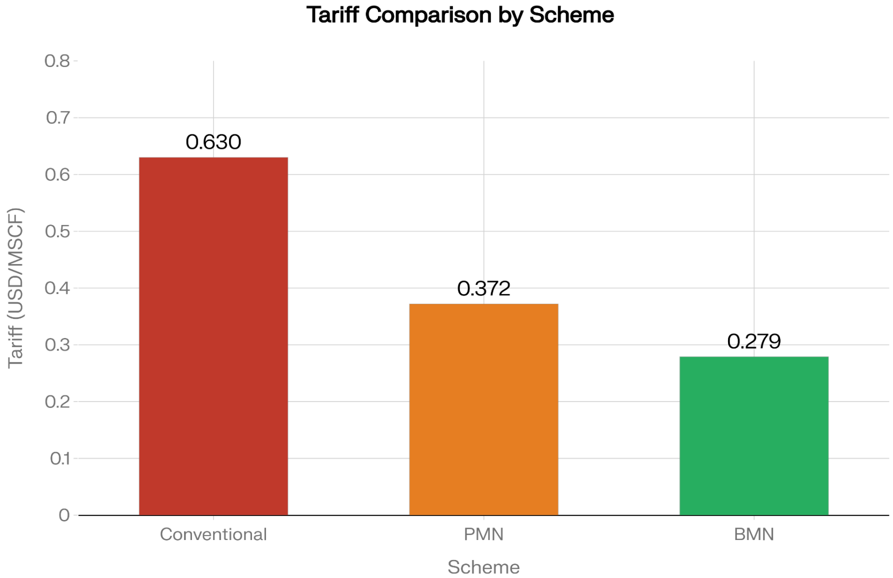

Figure 1. Tariff comparison, conventional, PMN, and BMN schemes (USD/MSCF).
This illustrates the Comparison of conventional, PMN, and BMN transmission tariffs for Cisem Phase I (USD/MSCF). The BMN scheme yields the lowest tariff at USD 0.279/MSCF, followed by the PMN scheme at USD 0.372/MSCF, while the conventional WACC-based scheme produces the highest tariff at USD 0.630/MSCF.

Sensitivity analysis findings

Table 3 and Figure 3 present the sensitivity analysis results.

The sensitivity analysis yields three principal findings. First, the BMN scheme is structurally immune to IRR-driven tariff volatility (Table 3, rows 2–3). Second, a 20% volume increase reduces per-unit tariff by approximately 16–18% across all schemes (Figure 3). Third, under PMN, reducing the equity fraction (increasing debt) lowers WACC through the tax deductibility of interest on debt (Brigham & Pettway 2009; Siswanto 2011; Brigham & Houston 2009).

Table 3. Sensitivity analysis: impact of key variables on tariff (USD/MSCF)

Variable changed	Change	Conv.	PMN	BMN
Base Case	,	0.630	0.372	0.279
IRR/Coupon	+1 pp	0.647	0.383	0.279*
IRR/Coupon	−1 pp	0.613	0.361	0.279*
Volume	+20% (40.1 MMSCFD)	0.525	0.310	0.233
Volume	−20% (26.7 MMSCFD)	0.788	0.465	0.349
Equity/Debt	50/50 @ 7% debt	0.572	0.341	0.279*
Equity/Debt	70/30 @ 7% debt	0.612	0.363	0.279*

*BMN immune to IRR and equity/debt variation (CAPEX = 0).

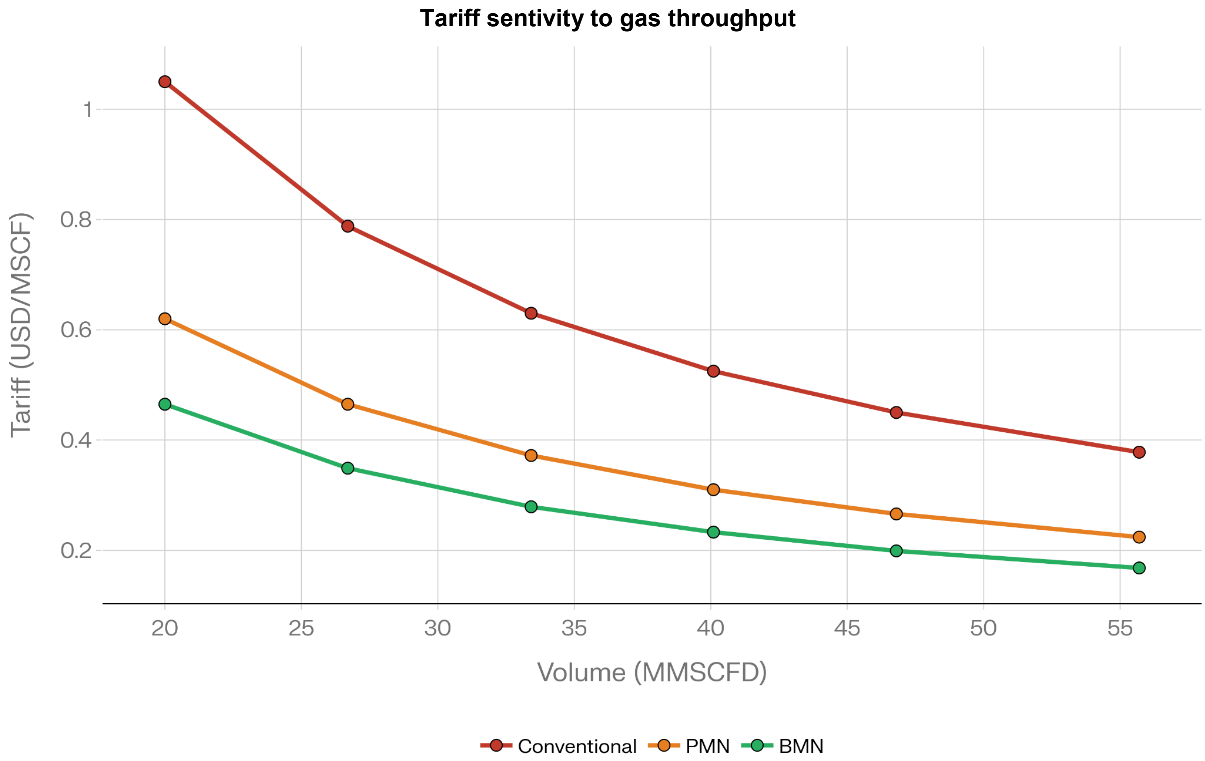

Figure 3. Tariff sensitivity to gas throughput volume, All Three Schemes (USD/MSCF).
This illustrates the sensitivity of transmission tariff to gas throughput volume under the conventional, PMN, and BMN schemes (USD/MSCF). The figure shows that tariffs decline as throughput increases in all schemes, and that the BMN scheme remains the lowest-cost option throughout the evaluated volume range.

Engineering professionalism and K3L

The research was conducted in full compliance with Indonesian professional engineering standards, in accordance with BPH Migas SOPs, with methodologies transparently documented, and with reporting to the BPH Migas Committee. All K3L protocols were observed throughout all field activities, including mandatory PPE use and compliance with the Integrated Quality, Environment, and K3 Management System (Mohitpour et al., 2007).

CONCLUSION

This study develops and validates the first techno-economic tariff framework specifically designed for government-financed, open-access natural gas transmission pipelines in Indonesia. Applied to the Semarang-Batang (Cisem Phase I) pipeline, two models are formulated: the PMN scheme, which recovers capital at the retail sukuk coupon rate (3.97%) and yields a tariff of USD 0.372/MSCF; and the BMN scheme, which waives capital recovery entirely and yields the minimum achievable tariff of USD 0.279/MSCF.

The BMN scheme delivers a 55.7% tariff reduction relative to the conventional WACC-based formula (USD 0.630/MSCF) and a 25.0% reduction relative to the PMN scheme. These reductions represent a structural mechanism for translating government infrastructure investment into downstream industrial competitiveness, demand stimulation, and indirect fiscal returns through taxes, levies, and BLU fees.

The BMN scheme is recommended as the optimal tariff model for APBN-financed pipelines where the primary policy objective is downstream market development. Future research should extend this framework to Cisem Phase II and other government-funded pipeline segments, incorporating real-time demand data as industrial development in the Central Java corridor matures.

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DECLARATIONS

Author contribution

A.A. Bawono: conceptualization, methodology, investigation, data curation, formal analysis, software, visualization, writing original draft, writing review & editing. S. Kartohardjono: supervision, methodology, validation, writing review & editing.

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Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

The use of AI or AI-assisted technologies

The author(s) used AI-assisted writing tools to assist in manuscript preparation, including language refinement, summarizing reference sources, and supporting the synthesis of findings in the systematic literature review (SLR). After using this tool, the authors reviewed, verified, and edited the content as needed and take full responsibility for the publication's content.

GLOSSARY OF TERMS AND SYMBOLS

Terms & Symbols	Definition	Unit
APBN	State budget (state revenue and expenditure budget of Indonesia)	

BMN	State property (government-owned asset)	
BLU	Public service agency (operator of state-owned public services)	
BPH Migas	Downstream oil and gas regulatory agency, indonesia	
CAPEX	Capital expenditure	USD
Cost of Service	Total annual cost of service	USD/year
CRF	Capital recovery factor	
ESDM	Ministry of energy and mineral resources, indonesia	
IRR	Internal rate of return	%
KITB	Batang integrated industrial zone	
MSCF	Thousand standard cubic feet	MSCF
MMSCFD	Million standard cubic feet per day	MMSCFD
NPV	Net present value	USD
O&M	Operations and maintenance costs	USD/yr
PMN	State capital participation (penyertaan modal negara)	
Tariff	Natural gas transmission tariff	USD/MSCF
WACC	Weighted average cost of capital	%
K3L	Occupational health, safety and environment	

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