

Tariff calculating model for natural gas transportation through open access transmission pipeline with multi tariff system to increase gas usage as clean energy

A A Bawono¹, E Kusri¹

¹Department of Chemical Engineering, Faculty of Engineering Universitas Indonesia, Kampus Baru UI, Depok 16424; Corresponding Author: Tel.:62-85647166568, 62-21-7863516 Ext. 204; fax: 62-21-7863515;

E-mail: ajiagraningbawono@yahoo.com

Abstract. The purpose of this study is to model the different tariffs on the transportation of natural gas through a pipeline for several shipper classes in an open access natural gas pipeline transmission line called a multi-tariff system. The determination of the natural gas tariff through the Open Access pipeline in Indonesia is mostly set using a distance system with the same value for all types of the shipper. The principle of justice is considered to be achieved from uniform tariffs for all the shipper, whereas in practice the separation of tariffs for each shipper group is currently essential. The proposed new tariff modeling is done by modifying the initial equations of the single-tariff model. Besides giving a new model proposal of tariff calculation for the multi-tariff system, in this research will also be modified free cash flow for new tariff calculation scheme and will be done the validity test on the formula. So that will get a multi-tariff calculation model which can become one of proposal material enter for Regulators to be able to set a fair tariff for the shipper without changing the economics of the transporter and can produce competitive gas prices to substitute clean energy sources for certain consumers such as electricity generation.

1. Introduction

Natural Gas is one of the clean energy sources that can be utilized for various needs, both for fuel power generation, industry, transportation and for household and commercial needs [1] [7]. The main problem in the regulation of the transportation of Natural Gas through the pipeline is the determination of tariff or cost of transportation. In determining the tariff, it must be accommodated to the interests of all parties, namely the transporter (the owner of the pipeline) and the shipper (the party using the pipeline) [9]. Determination of tariff for natural gas through the open access pipeline in Indonesia mostly determined using distance system with the same scale for all types of shipper on one segment of transmission pipeline, called as a single tariff [6], formulated by the following equation [4] [8]:

$$\text{Tariff} = \frac{\text{depreciation} + (O \& M) + (A \& G) + (Tax) + (Levy) + M \text{ arg in}}{\text{Single Volume}} \quad (1)$$

The principle of fairness is deemed to be achieved from uniform tariffs for all such shipper, whereas in practice, in a pipe segment there can be a receiving point or a point of delivery of each



different shipper [10]. The gas volume of each different shipper as well as the different gas utilization purposes (Industries, power plants, fertilizers, transportation, small and household customers) that require different policies for each tariff-related group that will be established. The purpose of this study is to model the different tariff calculations on the transportation of natural gas for several groups of the shipper in an open access pipeline transmission line called a multi-tariff system. So it can create a reasonable gas price without harming all parties and expected gas prices through a competitive pipeline compared to other more polluted fuel sources, which will encourage the substitution of gas usage as a clean energy source.

2. Method

The research procedure is done by the first step in the form of problem identification, then conducted literature study and data collection. To create a new modeling of tariff calculation for multi tariff system, the calculation of the formula of the general equation of single tariff calculation which has been determined by the previous regulator. The new equation is derived on the basis that the revenue derived from the single tariff system must be the same as the multi tariff system so that no party loses from the development of this scheme. With a multi tariff system, it is expected that each shipper pays a fair tariff according to the class determined based on the amount of natural gas volume that each shipper pours in a transmission pipe. To create a new modeling of tariff calculation for multi tariff system, the calculation of the formula of the general equation of single tariff calculation which has been determined by the previous regulator. The new equation is derived on the basis that the revenue derived from the single tariff system must be the same as the multi tariff system so that no party loses from the development of this scheme. With a multi tariff system, it is expected that each shipper pays a fair tariff according to the class determined based on the amount of natural gas volume that each shipper pours in a transmission pipe.

3. Result and Discussion

3.1. Proposed development of tariff calculation model for multi tariff system

By the general tariff equation, that tariff with the single system on a gas transmission pipe, formulated by the following equation [4] [9] [11]:

$$\text{Tariff} = \frac{\text{Cost of Service}}{\text{Volume}} \quad (2)$$

$$\text{Tariff} = \frac{(d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA)}{V} \quad (3)$$

Where, *O&M* is operating and maintenance costs, *A&G* is administration and general fee, *d* is depreciation of CAPEX, *T* is Tax costs, *L* is Regulator levy, *V* is volume of natural gas flowing, *NBA* is Asset base value (CAPEX), and *WACC* is Weighted Average Cost of Capital = IRR.

Weighted Average Cost of Capital is formulated with the following equation [5] [8] [10]:

$$WACC = CoE \frac{E}{E+D} + CoD \frac{D}{E+D} \quad (4)$$

Where *CoE* is the Cost of Equity, *CoD* is the Cost of Debt, *E* is Equity, and *D* is a Debt. The cost of Equity (CoE) and Cost of Debt (CoD) can be calculated by the following equation [2] [3]:

$$CoE = R_f + \beta(ICRP + BPMEM) \quad (5)$$

$$CoD = i \times (1 - T) \quad (6)$$

Where *R_f* is Risk-Free Rate, US Treasury Bond, Beta (*β*) is a measure of an investment portfolio fluctuation compared with the market (stock market), *ICRP* is Indonesia Country Risk Premium, *BPMEM* is based premium for the mature equity market, *I* is the interest rate, and *T* is Tax. From equation (3) we can derive the following equation:

$$\text{tariff} \times \text{volume} = (d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA) \quad (7)$$

$$\text{Revenue} = \text{tariff} \times \text{volume} \quad (8)$$

$$\text{Revenue} = (d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA) \quad (9)$$

In a multi-tariff system, the division of classes can be done based on the volume of natural gas entered by each group of shipper groups into the pipe. It can be modeled that each shipper class with each tariff group will enter the gas volume into the pipeline with the following equation:

$$\text{Shipper Group 1 (large gas volume) with } t_1 \text{ tariff, with volume} = V_1 \quad (10)$$

$$\text{Shipper Group 2 (medium gas volume) with } t_2 \text{ tariff, with volume} = V_2 \quad (11)$$

$$\text{Shipper Group 3 (small gas volume) with } t_3 \text{ tariff, with volume} = V_3 \quad (12)$$

$$\text{Shipper Group } n \text{ with } t_n \text{ tariff, with volume} = V_n \quad (13)$$

Where n is the division of classes or group. Then the total existing gas volume flowing in the pipe can be formulated by the equation:

$$V_{\text{total}} = V_1 + V_2 + V_3 + \dots + V_{n-1} + V_n \quad (14)$$

If the single tariff is developed, it is divided into several classes according to the multi-tariff system with the limitation that the multi tariff system must maintain the existing condition. So that the transporter economy does not change, then it can be formulated that the sum of revenue from multi tariff must be equal to Income from the original tariff so that it can be described by equation model as follows:

$$\text{Revenue}_{\text{multitariff}} = \text{Revenue}_{\text{existing}} \quad (15)$$

$$(t_1 \times V_1) + (t_2 \times V_2) + (t_3 \times V_3) + \dots + (t_{n-1} \times V_{n-1}) + (t_n \times V_n) = t_{\text{existing}} \times V_{\text{total}} \quad (16)$$

So by substituting equation (7) into equation (16), assuming the tariff is divided into three groups, it will be obtained the development of equation for the multi-tariff system to be:

$$(t_1 \times V_1) + (t_2 \times V_2) + (t_3 \times V_3) = (d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA) \quad (17)$$

So by substituting equation (7) into equation (16), assuming the tariff is divided into three groups, it will be obtained the development of equation for the tariff calculation with multi-tariff system to be:

$$t_1 = \text{tariff of group 1 (shipper with large volume)} \quad (18)$$

$$t_2 = at_1, \text{ tariff of group 2 (shipper with medium volume)} \quad (19)$$

$$t_3 = bt_1, \text{ tariff of group 3 (shipper with small volume)} \quad (20)$$

$$t_n = xt_1, \text{ tariff of group } n \quad (21)$$

Where,

$$a = \frac{V_2}{V_1}, b = \frac{V_3}{V_1}, \text{ and } x = \frac{V_n}{V_1} \quad (22)$$

Substituting equations (18), (19), and (20) into equation (17), we obtain the following equation:

$$(t_1 \times V_1) + (at_1 \times V_2) + (bt_1 \times V_3) = (d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA) \quad (23)$$

Substituting equation (22) into equation (23), we obtain the following equation:

$$(t_1 \times V_1) + \left(\frac{V_2}{V_1} t_1 \times V_2 \right) + \left(\frac{V_3}{V_1} t_1 \times V_3 \right) = (d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA) \quad (24)$$

$$(t_1 \times V_1) + \left(t_1 \times \frac{V_2^2}{V_1} \right) + \left(t_1 \times \frac{V_3^2}{V_1} \right) = (d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA) \quad (25)$$

$$\left(V_1 + \frac{V_2^2}{V_1} + \frac{V_3^2}{V_1} \right) \cdot (t_1) = (d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA) \tag{26}$$

$$\cdot t_1 = \left(\frac{(d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA)}{V_1^2 + V_2^2 + V_3^2} \right) \cdot V_1 \tag{27}$$

The equation model for group-n is as follows:

$$t_n = xt_1 \tag{28}$$

$$t_n = x \cdot \left(\frac{(d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA)}{V_1^2 + V_2^2 + V_3^2 + \dots + V_{n-1}^2 + V_n^2} \right) \cdot V_1 \tag{29}$$

$$t_n = \frac{V_n}{V_1} \cdot \left(\frac{(d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA)}{V_1^2 + V_2^2 + V_3^2 + \dots + V_{n-1}^2 + V_n^2} \right) \cdot V_1 \tag{29}$$

$$t_n = \left(\frac{(d) + (O \& M) + (A \& G) + (T) + (L) + (WACC \times NBA)}{V_1^2 + V_2^2 + V_3^2 + \dots + V_{n-1}^2 + V_n^2} \right) \cdot V_n \tag{30}$$

If the single tariff is calculated for a period, then equation (3) will be as follows:

$$tariff = \sum_{i=1}^t \frac{(d)_i + (O \& M)_i + (A \& G)_i + (T)_i + (L)_i + (WACC \times NBA)_i}{V_i} \tag{31}$$

In the same way, the new equations for multi-tariffs if calculated within a particular time (t) are as follows:

$$multi - tariff_{(n)} = \sum_{i=1}^t \left(\frac{(d)_i + (O \& M)_i + (A \& G)_i + (T)_i + (L_{total})_i + (WACC \times NBA)_i}{V_1^2 + V_2^2 + V_3^2 + \dots + V_{n-1}^2 + V_n^2} \right) \cdot (V_n)_i \tag{32}$$

3.2. Validation of proposed calculation model with manual simulation result of cash flow multi-tariff calculation

To prove that the development of the calculation model equation for the above multi tariff is valid and can produce the same result with the simulation result with cash flow manually, then the validation test is done. Validation is done by tariff case study for gas transportation through pipeline X previously calculated by single tariff system then modeled with the multi-tariff system using two method that is the simulation of cash flow development manually and through calculation with new equation model that has been derived. The results obtained are as follows (see table 1 and table 2). From the calculation result of the case study of pipe segment X and the result of comparison obtained, it can be concluded that the new equation model for multi-tariff calculation is valid because the multi-tariff calculation using the simulation of cash flow development compared with through the new equation model that has been derived produce a similar result.

Table 1. Economic and technical data of pipeline X

NBA and O&M	33,524,000 USD and 8,180,360 USD/year with escalation
Depreciation Time and Inflation rate	10 Year and 1.31 %
Rf, BP MEM, ICRP, and β	2.14% , 5.70%, 3.24%, and 1.070
Coe and CoD	11.71% and 0%
D and E	0 USD and 33,524,000 USD
Tax and interest (i)	25% and 0
WACC	11.71%
Gas Volume Total	150 MMScf/day
Category 1 (Shipper with large volume > 50 MMSCFD)	75 MMScf/day
Category 2 (Shipper with medium volume 10-50 MMSCFD)	45 MMScf/day
Category 3 (Shipper with small volume 0-10 MMSCFD)	30 MMScf/day

Table 2. Calculation Result, Validation and Tariff Comparison

Parameter	Single Tariff	Multi Tariff	
		Manual Cash Flow	New Model
Tarif (USD/MSCF)			
Category 1 (Shipper with large volume)	0.2789	0.3672	0.3672
Category 2 (Shipper with medium volume)		0.2203	0.2203
Category 3 (Shipper with small volume)		0.1469	0.1469
Total Revenue (USD)	152,796,993	152,802,798	152,802,798
Δ Revenue	0.004%		

From the results above can be seen that the tariff for category 3 is the cheapest tariff because it is a group that must receive a special rate because it concerns the public interest that must be subsidized. Tariff For other categories will be adjusted because it is a group based on profit orientation as high as possible. It can also be proven that the revenue earned between single tariffs and multi tariffs is not different. It can be proved that the result of deviation of revenue obtained from single tariff method compared with multi-tariff got a very small result, only by 0.004% (see table 2).

3.3. The result of comparison of tariff calculation with single tariff system with multi-tariff to produce more competitive gas price for particular group

In the pipeline X, there are several shipper classes, where there is a particular shipper group that should get a lower and fairer tariff than other shipper groups. The shipper of certain groups is channeling gas for special needs and subsidized so as to produce competitive prices and not burden the state budget and society widely. This particular shipper, among others, for the needs of electricity and fertilizer are arranged and subsidized profit because it has a broad impact on the community. Tariff is one of the components of gas price forming up to end user or consumer. The equation for calculating gas price through the pipeline to a consumer can be formulated by an equation as follows:

$$\text{Gas Price} = \text{Production Price} + \text{Transmission Tariff} + \text{Distribution Cost} + \text{Tax} \quad (33)$$

If previously with a single tariff method all shipper must pay the same tariff without differentiated class, so that particular group of subsidized shipper will pay the same tariff as the shipper which is a business entity with profit-oriented, so the principle of justice is not achieved. With cheaper rates, certain types of ships such as electricity and fertilizers will increase the attractiveness to switch to cleaner and cheaper gas energy sources than fuel oil. The results of calculation and comparison of gas price for certain class shipper before and after using multi tariff system are as follows (see table 3 and table 4):

Table 3. Result of calculation and gas price comparison for pipe X

Parameter	Production Price (USD/MMBtu)	Gas Transmission Tariff (USD/MMBtu)	Distribution Cost (USD/MMBtu)	Tax	Total Gas Price (USD/MMBtu)
Single Tariff	6.75	0.2789	0	0.028	7.0568
Multi Tariff	6.75	0.1469	0	0.015	6.9116

Table 4. Fuel price calculation and price comparison for specific shipper energy source

Energy Requirement (MMSCFD)	Energy Required (Assumed : 1 Scf=1000 Btu) (MMBtu/day)	High Speed Diesel		Natural Gas Pipeline With Single Tarif		Natural Gas Pipeline With Multi Tarif	
		HSD Price (USD/MMbtu)	Total Cost (USD/Day)	Gas Price (USD/MMbtu)	Total Cost (USD/Day)	Gas Price (USD/MMbtu)	Total Cost (USD/Day)
30	30,000	26	780,000	7.06	211,705	6.91	207,347
		Savings		568,295		572,653	

4. Conclusion

Modeling different tariff calculations on the transport of natural gas through pipes for several classes of the shipper in an open access pipeline transmission line called a multi-tariff system can create a fair gas price without harming all parties. Gas prices will be obtained through a competitive pipeline compared to fuel oil sources, which will encourage the substitution of gas usage as a cleaner energy source.

5. Acknowledgement

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