Operation and maintenance financial feasibility analysis of centralized domestic wastewater treatment system

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Operation and maintenance financial feasibility analysis of centralized domestic wastewater treatment system (case study: Palembang City Sewerage Project)

Key words: financial feasibility, wastewater, sewerage, operation and maintenance

Introduction

The lack of proper sanitation access in Indonesia, especially centralized domestic wastewater infrastructure, largely caused by budget insufficiency, for both construction and operation/ /maintenance cost (Kerstens, Legowo & Gupta, 2012; Pham & Kuyama, 2013; Kerstens, Leusbrock & Zeeman, 2015; Bergkamp, Setiadi, Adisurya & Lim, 2018). This condition led to high backlog for proper sanitation access (Bergkamp et al., 2018). Numerous studies have documented the importance of the financial feasibility on sewerage construction phase (Wedgwood & Sansom, 2003; OECD, 2004, 2007; Kerstens et al., 2012; Eales, Blackett, Siregar & Febriani, 2013; Kearton, 2013; Sugiana, 2013; Yengejeh, Davideh & Baqeri, 2014; Kerstens et al., 2015; McNamara, 2018; Wijaya & Soedjono, 2018; Fitriani, Putra & Juliantina, 2019).

While financially not beneficial, the centralized domestic wastewater infrastructure in Indonesia still built on economic benefit premise (Eales et al., 2013; Kearton, 2013). Main factor that made it not beneficial is the uncertainty on operation and maintenance phase (Kerstens et al., 2015). Low user tariff added with slow development for sewer connection, made the infrastructure built in past years become unproductive. Adding options such as grant or loan to elevate the financial feasibility on operation and maintenance phase thought to be effective to resolve the problems (Sugiana, 2013).

The aim of the research was to analyze the financial feasibility on operation and maintenance phase of Palembang City Sewerage Project using net present value (*NPV*), benefit cost ratio (*BCR*), and internal rate of return (*IRR*) calculation based on cost and revenue variable. The satisfactory conditions are: $NPV > 0$, $BCR > 1$, and $IRR > MARR$. Should the conditions did not meet, follow up analysis to improve the results by calculate different scenarios should be done.

Material and methods

This research used Palembang City Sewerage Project Phase 1 as case study. Palembang City Sewerage Project is a project located in Palembang City, South Sumatra Province, Indonesia. The aim of this project is to solve the domestic wastewater problems in Palembang, by providing the centralised domestic wastewater treatment system in Palembang, that designed for 22,000 connections city-wide (KIAT, 2017). Phase 1 of Palembang City Sewerage Project starts in 2017 and will be finished in 2022 with 4,064 household and 2,229 commercial connection as main objective funded by Government of Indonesia Budget. The later expansion in Phase 2 to fill the maximum capacity of the wastewater treatment plant will be funded by the South Sumatra Provincial Budget and Palembang Municipality Budget in 2025.

Financial analysis on operation and maintenance of centralized domestic wastewater treatment system, emphasize on budget analysis to determine the feasibility of said phase financialy (Kvernberg, 2012; Yengejeh et al., 2014). Based on OECD (2004), the analysis needed to provide financing options and assurance when the operator solely dependent on tariff revenue to operate and maintain the system. The analysis also needed to prevent high idle capacity and fail system, caused by rejection to pay from the customers (Wedgwood & Sansom, 2003).

Based on previous study, cost and revenue variable chosen to be calculated for this project operation and maintenance financial feasibility. The revenue variable consists of household and commercial tariff, while the cost variable consist of: (a) chemical usage cost, (b) sludge disposal cost, (c) personnel wage cost, (d) fuel and electricity cost, and (e) spare-part replacement cost (OECD, 2004, 2007; van Buuren, 2010; Rosaria, 2010; Kvernberg, 2012; Sugiana, 2013; Kerstens et al., 2015; KIAT, 2017; McNamara, 2018; Fitriani et al., 2019).

During this research, first hand information on prices in Palembang was obtained during site visit and through discussions with involved stake-holders. The data obtained from the Ministry of Public Works and Housing (MOPWH) was willingness-to-pay survey results that involved 100 respondent, each from, household and commercial connection targets. As for cost variable data, were obtained from both MOPWH and PDAM Tirta Musi as the operator candidate for the system.

The analysis were calculated using discounted cash flow techniques (DCF) in worksheet computer application. The DCF was choosen because the calculation results affected by time value of money. Time value for money is a conjecture that money has different value in different period of time. The analysis should also: (a) simple to understand, (b) easy to calculate, (c) measures profitability, (d) ensures liquidity, (e) can adjust for risks, and (f) considers all cash flows (Bhandari, 2009; Maroyi, 2011). Thus the analysis calculate net present value (*NPV*), benefit to cost ratio (*BCR*), and internal rate of return (*IRR*) to determine the feasability.

As previously stated, the financial feasibility was determined using *NPV*, *BCR*, and *IRR*. Net present value, presented in Eq. (1), is the difference between the present value of cash inflows (C_t) and the present value of cash outflows (C_o) over a period of time. All cash flows are discounted to present values using the required rate of return (r). The desirable result show by positive value of the calculation ($NPV > 0$). The applied currency rates based on Government of Indonesia official exchange rates were 14,500 Indonesian rupiah to 1 US dollar (Rp/USD). A 8.9% of discount rate for 20 years are applied in Eqs. (1) and (2).

$$NPV = \sum_{t=0}^{T} \left(\frac{C_t}{(1+r)^t} \right) - C_o \qquad (1)$$

Benefit to cost ratio defined as the ratio of the present value of future cash inflows to the cash outflows. Mathematically, this can be calculated using Eq. (2). The result deem satisfactory if the result is larger than one. Internal rate of return defined as the rate at which the net present value of project equals of zero. The satisfactory condition for the calculation met if the value of the calculated rate is larger than minimum acceptable rate of return ($IRR > MARR$). The use of *NPV*, *BCR*, and *IRR* calculation to determine the financial feasibility was applied by Prihandrijanti, Malisie and Otterpohl (2008), and Kerstens et al. (2015).

$$BCR = \frac{revenue\ PV}{cost\ \ PV} \qquad (2)$$

Follow up analysis to improve the feasibility taken when the satisfactory conditions did not met. The aim of follow up analysis was to improve the result of *NPV*, *BCR*, and *IRR* calculations to meet the satisfactory conditions. Following scenarios is choosen based on input from PDAM Tirta Musi as operator candidate for follow up analysis: (a) tariffs adjustment analysis, (b) analysis on adding grant as option, and (c) analysis on adding loan as option.

Results and discussion

Base assumption

The input data for the calculation, shown in Table 1, consists of base assumption of cost and revenue variable. Using the data provided, *NPV*, *BCR*, and *IRR* then calculated and showed these results: NPV = USD – 4,239,448.28, BCR = 0.8719, and IRR = –5%. These results did not meet the satisfactory conditions, thus the follow up analysis to improve the results taken.

Follow up analysis

1. Tariff adjustment
   Tariff adjustment analysis was taken to determine minimum tariff to meet the satisfactory conditions. The tariff adjustment calculation done with following conditions: (a) adjust household tariff with 100% increment, while commercial tariff fixed, and (b) adjust commercial tariff with 10% increment, while household tariff is fixed. The result presented in Table 2.

TABLE 1. Base assumption of cost and revenue variable (MOPWH and PDAM Tirta Musi)

Variable		Value [USD]
Cost	chemical usage	6 896.55 per month = 82 758.62 per year
	sludge disposal	1 022 400 per year
	personnel wage	3 655.17 per month = 43 862.07 per year
	fuel and electricity	14 513.79 per month = 174 165.52 per year
	spare-part replacement	10 344.83 per year; 689 655.17 per 10 year; 13 793 103.45 per 20 year
	depreciation (flat)	2 068 965.52 per year
Revenue	household tariff	0.76 per month
	commercial tariff	20.69 per month
	installation cost (1 time)	344.83

TABLE 2. Tariff adjustment analysis (own studies)

Tariff base assumption [USD]		Tariff adjustment [USD]		Escalation [%]
Household	0.76	$NPV > 0$, $BCR > 1$	8.28	1 000
		$IRR > MARR$	26.21	3 355
Commercial	20.69	$NPV > 0$, $BCR > 1$	31.03	50
		$IRR > MARR$	60.00	190

As shown in Table 2, the tariff adjustment for household to meet satisfactory condition of *NPV* and *BCR* is 1,000% increase from base tariff, and to meet the satisfactory condition of *IRR* the tariff need to increase 3,355%. For the commercial tariff, minimum 50% escalation from base tariff needed to meet *NPV* and *BCR* desirable results, and 190% escalation to make the $IRR > MARR$.

2. Grant

Adding grant as option to improve the feasibility was calculate as shown in Tables 3 and 4, following these scenarios:

a. Grant for sewer connection expansion

Grant that given one time to expand the sewer connection until reached the maximum amount of 22,000 sewer connection.

b. Grant for tariff subsidy

Recurring grant to give subsidy for base tariff, in order to prevent financial loss for sewerage operator.

As stated on the calulations in Tables 3 and 4, the total grant needed to achieve maximum sewer connection is 5,416,207 USD for 20 years or anually 270,810.35 USD. The amount of grant needed for subsidy is bigger compared to the grant needed for sewer expansion.

TABLE 3. Grant for sewer connection expansion (own studies)

Scenario	Connection type	Number of connections	*NPV* [USD]	*BCR*	*IRR* [%]	Total grant [USD]
Base asumption	household	4 064	–4 239 448	0.87	–5	–
	commercial	2 229				
Maximum household connection	household	19 771	20 719 103	1.64	13	5 416 207
	commercial	2 229				
Maximum commercial connection	household	4 064	43 270 207	2.33	23	5 416 207
	commercial	17 936				

TABLE 4. Grant for tariff subsidy (own studies)

Connection type	Number of connec-tions	Base tariff	Tariff adjust-ment	Monthly subsidy	Annual subsidy	*NPV*	*BCR*	*IRR* [%]
		[USD]						
Household	4 064	0.76	8.28	30 550.07	366.600.83	211 517.24	1.01	0
			26.21	103 421.79	1 241 061.52	11 383 655.17	1.35	9
Commercial	2 229	20.69	31.03	23 058.62	276 703.45	646 206.90	1.02	1
			60.00	87 622.76	1 051 473.10	11 488 551.72	1.35	9

3. Loan
   Adding loan as option to improve the feasibility, shown in Table 5, was calculate using these scenarios:
   a. Loan for 100% maximum household connection expansion, with 20 years flat reimbursement.
   b. Loan for 50% maximum household connection expansion + + grant for 50% maximum household connection expansion, with 20 years flat reimburesment.
   c. Loan for 75% maximum household connection expansion + + grant for 25% maximum household connection expansion, with 20 years flat reimburesment.
   d. Loan for 100% maximum commercial connection expansion, with 20 years flat reimbursement.
   e. Loan for 50% maximum commercial connection expansion + grant for 50% maximum commercial connection expansion, with 20 years flat reimburesment.
   f. Loan for 75% maximum commercial connection expansion + grant for 25% maximum commercial connection expansion, with 20 years flat reimburesment.

Based on Table 5, adding loan is proven to improve the financial feasibility, shown by the improvement on *NPV*, *BCR*, and *IRR* calculation results.

TABLE 5. Loan analysis for Palembang City Sewerage Project (own studies)

Scenario		Number of connections		Loan	Grant	*NPV*	*BCR*	*IRR* [%]
		household	commercial	[× 1 000 USD]				
a	Maximum household, 100% loan	19 771	2 229	5 416.21	–	17 833.65	1.51	11
b	Maximum household, 50% loan + 50% grant	19 771	2 229	2 708.10	2 702.70	19 185.34	1.57	12
c	Maximum household, 75% loan + 25% grant	19 771	2 229	3 712.07	1 699.04	18 659.17	1.55	11
d	Maximum commercial, 100% loan	4 064	17 936	5 416.21	–	33 053.74	1.95	17
e	Maximum commercial, 50% loan + 50% grant	4 064	17 936	2 708.10	2 694.63	34 386.30	2.03	19
f	Maximum commercial, 75% loan + 25% grant	4 064	17 936	3 870.00	1 536.98	33 767.14	1.99	18

Furthermore, the combination of loan and grant to expand both household and commercial connection shows a better results compared to expansion solely funded by loan.

Conclusions

The financial feasibility value of Palembang City Sewerage Project calculated based on base tariff for operation and maintenance phase, shows negative result. The budget needed for the operation and maintenance phase for Palembang City Sewerage Project was 2,450,620 USD or annually 78 USD per capita, it was bigger than the results found in Kerstens et al. (2015) for annually 16 USD per capita, or annually 8.5 USD per capita in Prihandrijanti et al. (2008).

Low user charge tariff makes the financial feasibility results did not meet satisfactory condition. Improvement using tariff adjustment found that a minimum of 1,000% for household tariff and 50% for commercial tariff needed to make the *NPV* and *BCR* results accepted. And further 3,355% and 190% escalation for household and commercial tariff needed to meet satisfactory conditions of *NPV*, *BCR*, and *IRR*.

These results need to be advocated to the user, to prevent rejection of willingness to pay from the user. It means that the external factor plays a large portion for the decision making, and the success rate is low for tariff escalation based on previous research (OECD, 2004; Prihandrijanti et al., 2008; van Buuren, 2010; Kerstens et al., 2012; Sugiana, 2013; Kerstens et al., 2015).

From authors' point of view, the options using combination of grant and loan is the best choice. The sewerage operator can make business plan and search for loan and grant to get the budget needed for both business expansions as well for operation and maintenance budget.

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Summary

Operation and maintenance financial feasibility analysis of centralized domestic wastewater treatment system (case study: Palembang City Sewerage Project). Budget needed for operation and maintenance of centralized domestic wastewater management in Indonesia is often overlooked. This results in fail systems, high idle capacity, and abandoned assets. While the economic feasibility often used as the basis for centralized domestic wastewater infrastructure construction, the financial feasibility often shown a different result. The construction phase will be feasible according the analysis, while the operation and maintenance phase will have a different result. As unsolicited projects, the operation and maintenance of sewerage in Indonesia always have budget difficulties, thus needed scenario to resolve the matter. In this study, cost and revenue variable will be analyzed to determine the feasibility value based on *NPV*, *BCR*, and *IRR* calculations. The revenue comes from user charge tariffs on household and commercials connections, and cost variable consists of: chemical usage cost; sludge disposal cost; personnel wage cost; fuel and electricity cost; spare-part replacement cost. The analysis will determine whether both household connection and commercials connection in the sewerage system have positive results. Should negative results emerged, follow up analysis added to elevate the results consists of following scenarios: sensitivity analysis for tariffs adjustment; sensitivity analysis adding grant as option; sensitivity analysis adding loan as option. While analysis of base tariffs shown negative results on *NPV*, *BCR*, and *IRR* calculation, the follow up analysis shown significant changes thus the results is desirable.

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