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THE IMPACT OF LRT BATAM TECHNOLOGY SELECTION ON FINANCIAL FEASIBILITY ANALYSIS

Herawati Zetha Rahman*, Dian Perwitasari, and Azaria Andreas

Department of Civil Engineering, Faculty of Engineering, Universitas Pancasila, Depok

ABSTRACT

Batam continues to experience an increase in mobilization and economic growth rates. The aviability of an effective, eficient, and adequate transportation is the solution for mobilization and economic growth in Batam. Developing a Light Rail Transit (LRT) in Batam is the offered solution. However, developing LRT requires high initial cost, and with the limitation of government fund, private is expected to take part in PPP (Public Private Partnership) scheme for project financing. One of many aspect that influencing financial feasibility is LRT technology selection. In this research, the technology selection will compare between 2 LRT technology, Cattenary LRT System and Non Cattenary LRT System. Quantitative approach along with Life Cycle Costing (LCC) analysis is used in this research. Result shows that Cattenary LRT system gives better financial feasibility than Non Cattenary LRT system.

Keywords: Batam, Cattenary System, Life Cycle Costing, LRT

1. INTRODUCTION

The development of railway network in Sumatera is aiming to realization of Trans Sumatera Railways according to National Railway Master Plan (*Rencana Induk Perkeretaapian Nasional*) connecting from Aceh Province to Lampung for 2.168 km. One part of the development of the railway network in Sumatera is located in Batam city. This city is a free trade and port zone manage by Badan Pengusahaan Batam (BP Batam). The rate of population growth along with economic in Batam has increased because of the free trade and port zone characteristic and so, it caused mobilization of people or goods increase annually.

2. LITERATURE REVIEW

2.1. Light Rail Transit Technology

The Light Rail Transit or LRT is one kind of mass transportation that has been used in many country, as well Indonesian government through Ministry of Transportation is also choose LRT in many railway development project across the country. LRT considered can change and improving quality of many things in a region or city such as connectivity, urban planning, economic, etc. It is called Light Rail because the rolling stock only has 20 ton in weight and moving with electricity as a power source. This Light Rail can reach 5-10 min headway between train sets, therefore it is an alternative to traffic jam solution. LRT has many type according to power source and electric current source location.

*Corresponding author: Email: zetha.hera@univpancasila.ac.id

A. Cattenary

In Cattenary system, the electric power to move LRT flowed using a conductor wire that extends at the top along the LRT route or known as overhead line/cattenary. Cattenary system divided into Direct Current (DC) and Alternating Current (AC), while the electric current flowed from traction substation. This traction substation consists of some panel and components such as trafo, silicon rectifier, DC switchgear, battery and charger. The battery is used from dry battery type, for this type the advantage are manual addition of water is not required and battery capacity will always maintained with the use of charger. The spesification of each panels and components inside traction substation depends on how much the electric current flowed.

Almost all of LRT used around the world today using overhead lines or cattenary system. However, along with current development and government awareness to urban planning, the used of cattenary system began to not popular. Some consideration that makes cattenary system began to abandoned are initial and maintenance cost, safety reason, and aesthetic of the city. Cost required for the construction of this rail includes railroad track, electrification such as wire, supporting construction, sub station, and other electrical equipment. Cost required for maintaining and operating LRT with cattenary is considerably. For the aesthetic reason, the used of wires along the LRT route is considered disturbing, especially when the route is through the historic area of the city. To support the development of better urban planning and tourism, the Non Cattenary LRT system is developed.

B. Non Cattenary

There are 2 main type of Non Cattenary LRT, Third Rail system and Battery or Super capacitor system.

Third Rail System

The development of third rail is used to replace the overhead line system where the electric wire placed at the ground side by side with the rail track it self. Some LRT manufacturer such as Alstom and Bombardier had develop a different third rail system. Alstom developed a sistem known as the Aesthetic Power Supply (APS) system. It consists of several power units placed beneath rail track in certain interval. Electricity flowed by conductor and later received by collector slippers located at the middle of rolling stocks.

The electricity also stored inside battery, hence if one of power units shut down, the LRT stil can move without distubing. Safety factor also considered when using this system, where electrification only works if the train pass on the third rail, and so safe for people walking. Bombardier developed a system known as Bombardier Primove System (BPS). BPS use a diffrent concept, electric induction. This BPS system consists segmentation of wires beneath rail track as a electric source power. Magnetic field will appeared when a segment activate. In a train set, there are several receiver that convert magnetic field energy into electrical power as a source energy to LRT. Magnetic field that appear also has a strong effect to another electrical gadget, and so this LRT system is still in a testing phase before it can be operate commercially.

Battery or Super Capacitor

Another technology developed for LRT is Battery or Super Capacitor. Additional civil works that needs to build for this system is a facility to accomodate charging system for battery or super capacitor. LRT with battery relatively has longer time to charging the battery, and wider operating distance, while LRT with super capacitor has a shorter time to charging the super capacitor (20 sec), but shorter operating distance. This LRT with battery also can be combined with cattenary LRT system.

Table 1. Different of LRT Using Battery and Super Capacitor
(*Global Mass TransitResearch)*

Feature	Battery	Super-Capacitor
Estimate life	20,000 cycles	100,000 cycles
Regeneratif energy application	No	Yes
Estimate cost	20% from rolling stock cost + replacement at the end of economic life	20% from rolling stock cost + replacement at the end of economic life
Charging duration	High	Low
Operating radius	High	Low

One of many city that operate LRT with battery system is Konya (Turks). It operate on a rail track that combined cattenary system and non cattenary system. Charging battery starts only when the LRT pass on catenarry track, while the battery used when the LRT pass on non cattenary track. As a world heritage that has been built since Roman times, the local government is not allowing a change in the cities view, therefore the cattenary system LRT is forbid to operate in some areas.

The LRT with battery in Konya will be operate on new track along 6 km, where half of it will be non cattenary system. Although LRT with this system has been widely used, researcher still develop the further technology. The weakness of battery system (longer time to charging) can be solved by super capacitor. The short duration of charging super capacitor makes this system suitable to use for storing the energy when LRT starts braking. Technically, the application of battery and super capacitor technology in LRT can be combined. The size of super capacitor depends on the LRT distance operating.

LRT with super capacitor technology is developed by CRRC Zhuzhou and Siemens. Charging the super capacitor will be automatically done between 10-30 second duration by a power supply. The charging takes place when the LRT stops at the station while passenger enter or leave the car. The charging also can be done using mobile charger system to anticipate damage to the charging at station. At full capacity, the LRT can operate as long as 4 km distance. During braking, 85% of brake energy will be convert and store as electricity power.

This LRT with 100% super capacitor operate at Guangzhou city in Tiongkok. Guangzhou LRT serves route between Canton Tower and Wanshengwei along 7.7 km with 10 station carrying 386 passenger with maximum speed 70 km/ hr.

C. Previous Research

Similar research that has been done is “Technology Selection In Airport Railway Project Using Value Engineering Approach” by Berawi et al (2013) which examined the selection technology for rail infrastructure in railway construction project between Halim Perdana Kusuma Airport and Soekarno Hatta Airport. PPP scheme will considered to be used for project financing, however because of the high initial cost of investment, it requires innovation and creative effort at construction planning without reducing the function. One can be done is with railway infrastructure technology

selection such as selecting the railway track component (slab track or ballasted track), electrification (250 KV AC or 2.500 V DC), and signalling components (Fixed Block or Moving Block).
Results show that the most appropriate railway infrastructure technology (track component, electrification, and signalling component) to be implemented in the project can gives IRR 9.11% dan NPV RP. 5,670,761,614,402.- for 30 years.

2.2. Financial Feasibility Analysis
Financial feasibility analysis has a purpose to analyze and evaluate the amount of investment to revenue from operating enterprise. The financial feasibility indicator that has been widely used to evaluate such as NPV, IRR, and Payback Period.
All of the indicators comparing between benefit and cost value from each alternative. But spesifically, each of the indicator has different characteristic, and so all of the indicator needs to be examined.

1. Net Present Value (NPV)
   NPV used to calculate whether a proposed project will create value added or not. The calculation of NPV consists of many financial topics such as: cash flows, time value of money, the discount rate over the duration of the project, etc. NPV can be calculate using this formula (Maric et al, 2011):

$$NPV = \sum_{n=0}^{t} \frac{N\,I_n^e}{\left(1+\frac{P}{100}\right)^n} \quad (1)$$

   A project is declared financially feasible if the NPV is positive, in this case construction can be proceed because it will give profit in the future along to the economic life of project. Otherwise, a project is declared financially unfeasible if the NPV is negative, but if the project is economically feasible, then it is necessary to find another possible scheme that allowing such infrastructure projects to be financially feasible.

2. Internal Rate of Return (IRR)
   This indicator is a condition of interest rate if the NPV = 0. IRR can be calculate using this formula (Maric et al, 2011):

$$\sum_{n=0}^{t} \frac{N\,I_n^e}{\left(1+\frac{P}{100}\right)^n} = 0 \quad (2)$$

   The prevailing interest rate must be less than IRR value of a project. If the prevailing discount rate also known as MARR (Minimum Attractive Rate of Return) less than IRR value of a project, then the project considered profitable. MARR value become a consideration for business entities to participate in government infrastructure projects.

3. Payback Period
   This indicator shows a period of time required to recoup the funds expended in an investment. Pay back period identified when NPV equal to zero, which is a period where the payback is fulfilled. If this period less than planned period, project considered feasible, if not, the project considered not feasible.

2.3. Batam LRT

According to Feasibility Study done by Ministry of PPN/ Bappenas in 2015, the priority line (route) of railway construction in Batam are Tanjung Uncang – Batam Center (line 1) and Hang Nadim Airport – Nagoya (line 2). Line 1 (27.54 km) has 23.5 km at grade track and 4.04 elevated track, while Line 2 consists of elevated track along 27.93 km.

In the first year of operation planned in 2022, demand at Line 1 and Line 2 estimates at 17,100 passenger/ day and 23,259 passenger/ day. The cost structure for this analysis are:

1. Cost components
   a. Capital Expenditure (CAPEX)
      CAPEX in this analysis is the Initial Cost between 7 construction alternatives, where construction duration estimates for 3 years (2018-2020) with progress assumption at 1st year 25%, 2nd year 50%, and 3rd year 25%.
   b. Interest During Construction
   c. During construction period, capital ratio assumption where 70% comes from loan
   d. Infrastructure depreciation and rolling stock replacement
   e. Operating and maintenance of infrastructure and rolling stocks

2. Revenue components
   a. Ticket revenue obtained from the amount of demand anually multiple by ticket price.
   b. Property development such as hotel and condominium / apartment in each line.
   c. Station revenue comes from 3 type station (Type A, B, and C). Type A station doesn't has commercial area, Type b station has kiosk/ outlet space that can be rented, while Type C station has kiosk/ outlet space and integrated with mall/ airport and so contribute to station revenue. Outdoor media such as billboard placed in three location, Type B and C station, in strategic location along the line, and inside or outside the bodycar of rail.

2. METHODOLOGY

This research using qualitative and quantitative approach, while the data collected using deep interview to experts in transportation especially rail transportation. Financial feasibility of technology selection in Batam LRT obtained from Life Cycle Costing (LCC) Analysis to calculate NPV and IRR value. Several assumption in LCC analysis are:

1. Operation and maintenance cost anually growth following inflation rate 6.5%
2. Rolling stock has useful life 30 years, at the first 30 years 2 car set rolling stock spesification is used, after 30 years the rolling stocks needs to haul with cost 50% of rolling stock cost. After 50 years the rolling stocks replace with 3 car set spesification to accomodate demand growth.
3. Battery replacement every 5 years for each car set with cost Rp. 26,000,000,000.-
4. At the first time operate, demand expectation estimates at 61% (moderate scale)
5. LCC analysis simulation using ticket price at Rp. 10,000.- and Rp. 12,500.-,

while the occupance level for property estimates at 65% and 75%.

6. Exchange rate for 1US$ is Rp13,000.- (2016)

3. RESULTS AND DISCUSSION

3.1. Initial Cost and Operation – Maintenance Cost

Railway cost of Batam LRT consists of Initial Cost (IC) and Operation and Maintenance Cost (OM). Inside this infrastructure cost, there are infrastructure components (elevated and at grade track), signalling and telecomunication components (Fiber Optic & Radio Link), electrification components, depo, and rolling stocks. See Table 2 below for more information.

Table 2. Initial Cost and OM Cost

Cost of Batam LRT	Line 1 (in Million Rp.)	Line 2 (in Million Rp.)
Initial Cost	3.435.160	9.450.179
OM Cost	52.505	99.767

After obtaining IC and OM, the next step is calculating financial feasibility for both line using LCC approach. Any assumption in calculating LCC can be seen at Methodology Section.

3.2. Cattenary LRT system LCC

Table 3. Cattenary System Financial Analysis

Concession years	Tariff Rp.	Occupancy Property %	Line 1			Line 2		
			NPV (in Million Rp.)	IRR (Real)	IRR (Nominal)	NPV (in Million Rp.)	IRR (Real)	IRR (Nominal)
50	10.000	65	-3016215.16	-2.45%	3.89%	-8,743,806.62	-3.18%	3.12%
		75	-2765162.87	-2.39%	3.95%	-8,376,640.23	-3.14%	3.16%
	12.500	65	-2712772.39	-0.94%	5.50%	-8,322,682.94	-2.16%	4.20%
		75	-2368133.08	-0.89%	5.56%	-7,826,567.00	-2.12%	4.25%
75	10.000	65	-2873963.79	0.45%	6.98%	-8,512,894.98	-0.38%	6.09%
		75	-2765162.87	0.48%	7.01%	-8,376,640.23	-0.36%	6.11%
	12.500	65	-2508271.09	1.38%	7.97%	-8,006,339.92	-0.30%	6.82%
		75	-2368133.08	1.41%	8.01%	-7,826,567.00	-0.32%	6.84%

Result shows that both for Line 1 and Line 2, the NPV value for cattenary LRT system is negative using both Rp. 10,000.- and Rp. 12,500.- ticket price. NPV still negative even if the concession period extends until 50 or 75 years.

3.3. Non Cattenary LRT system LCC

Table 4. Non Cattenary System Financial Analysis

Concession years	Tariff Rp.	Occupancy Property %	Line 1 NPV (in Million Rp.)	Line 1 IRR (Real)	Line 1 IRR (Nominal)	Line 2 NPV (in Million Rp.)	Line 2 IRR (Real)	Line 2 IRR (Nominal)
50	10.000	65	-3061403.14	-2.74%	-2.74%	-8,745,832.30	-3.31%	-2.98%
		75	-3027910.77	-2.68%	-2.68%	-8,686,931.94	-3.27%	-3.02%
	12.500	65	-2755828.88	-1.15%	-1.15%	-8,322,897.64	-2.25%	-4.10%
		75	-2722493.78	-1.09%	-1.09%	-8,264,006.76	-2.21%	-4.15%
75	10.000	65	-2947392.73	-0.10%	-0.10%	-8,555,336.85	-0.83%	-5.62%
		75	-2889855.02	-0.38%	-0.38%	-8,460,587.75	-0.42%	-6.05%
	12.500	65	-2586468.99	-0.98%	-0.98%	-8,056,510.96	-0.06%	-6.44%
		75	-2522260.21	-1.31%	-1.31%	-7,952,483.89	-0.27%	-6.79%

Result shows that both for Line 1 and Line 2, the NPV value for cattenary LRT system is negative using both Rp. 10,000.- and Rp. 12,500.- ticket price. NPV still negative even if the concession period extends until 50 or 75 years.

4. CONCLUSSION

When comparing 2 type LRT technology between Cattenary system and Non Cattenary system, result shows that technology with the most financially feasible is Cattenary system. It can be seen from NPV and IRR value, where Cattenary system get a better NPV and IRR value than Non Cattenary system.

From the results (Table 3 and Table 4) of the feasibility analysis, it can be concluded that both Cattenary system and Non Cattenary system for Line 1 and Line 2 obtained negative NPV value and IRR value below MARR.

According to the analysis, the development plan of Batam LRT is financially not feasibel to be built and operate along concession duration both 50 years and 75 years. According to the simulation, it is known that IRR value is sensitive to ticket price (Rp. 10,000.- and Rp. 12,500.-) and doesn't affected from property occupancy rate changes.

Therefore further studied is needed to examine the appropriate PPP (Public Private Partnership) scheme or known as KPBU (Kerjasama Pemerintah dan Badan Usaha) in Indonesia in order the development plan of batam LRT can be implemented.

REFERENCES

Berawi, M. A., Susantono, B., Miraj, P., Berawi, A. R. B., Rahman, H. Z., dan Husin, A.. (2014). "Enhancing Value for Money of Mega Infrastructure Projects Development Using Value Engineering Method". Procedia Technology, vol. 16, pp. 1037-1046.

Berawi, A. R. B., Rahman, H. Z., Zulkarnaen Mohammad. (2013). "Technology Selection In Airport Railway Project Using Value Engineereing Approach". Proceeding, International Conference on Advanced Technology to Support Sustainable Development, pp. C-64-71

Global Mass Transit Report. Global Rolling Stock and Railway Systems Report 2016-2025.

Maric, B., Kamberovic, B., Radlovacki, V., Delic, M., Zubanov, V.. (2011). "Observing the Dependence Between Dynamic Indicators of Investment Profitability – Relative Net Present Value and Internal Rate of Return". African Journal of Business Management, vol. 5 (26), pp. 10331-10337

Sintropher. (2015). Innovative Technologies for Light Rail and Tram: A European reference resource. University College London.

Zetha, H.R., Berawi, M,A., Sesmiwati., Susilowati and Dofir, A. (2012). “Application of Value Engineering at Public Private Partnership Project to Improve Quality of Feasibility Study (Case Study: Airport Railway in Indonesia)”. International Conference on Value Engineering and Management (ICVEM) Hongkong.