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Economic technology analysis of lte advanced pro dual spectrum licensed and unlicensed access using discounted cash flow methods

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ABSTRACT

Since implementing the long term evolution (LTE) technology, the surge in data service traffic has increased, causing an increase in demand spectrum, which has resulted in gaps in capacity requirements. Wireless service providers can respond to LTE technology updates. With LTE advanced pro technology that utilizes unlicensed spectrum technology can provide solutions to increase capacity and throughput. In this study, LTE advanced pro planning by capacity method to find the number of eNodeB and using the discounted cash flow method to analyze the feasibility of the costs to be invested in the implementation of the LTE. The results of the four simulated scenarios concluded that the number of eNodeB from the IV scenario with 20 MHz bandwidth at 1800 MHz frequency and 20 MHz bandwidth at 5 GHz frequency amounted to 23 sites, with a positive NPV value of $ 271,936.96, IRR of 14.91%, and for Payback Period occurred in the 3rd year. Thus the fourth scenario is feasible to be implemented.

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1. INTRODUCTION

Broadband technology in Indonesia continues to experience development, starting from the first generation technology (1G), up to the latest technology today, the fourth generation technology (4G), which has a speed of 100 Mbps in theory [1]. 4G technology is often referred to as 4G LTE, with the presence of long term evolution (LTE) technology, data service traffic has experienced significant growth, many users of the previous generation switched to utilizing 4G LTE technology [2]. The higher internet speed is directly proportional to the activity of internet users, which causes an increase in demand spectrum such as downloads, data uploads, video streaming, social media, online games, mobile cloud. Which previously did not work well with 3G technology, but with 4G LTE, technology can run well [3]. Computer network technology as a medium of communication between devices has made significant progress in terms of communication media. This is one of the fastest-growing internet applications now [4]. On the other hand, data traffic has increased by 131% since 2011. This has prompted several cellular operators in Europe to invest in machine-to-machine communication. However, existing mobile networks cannot accommodate exponential growth in data traffic [5]. Other factors supporting the increase in traffic are increasingly affordable smartphones, internet access devices that are increasingly easy to use, and tariff wars between telecommunications providers, this has an impact on mobile data demand that continues to increase. While the spectrum is increasingly limited, which leads to a gap in capacity requirements. And is expected to decrease to minus 500 MHz in 2020 [6]. By continuing to decline in the demand spectrum forecast in Indonesia, telecommunications providers must update LTE technology in anticipation of a higher demand spectrum, with LTE technology updating can increase capacity and throughput [7].

To improve the signal quality in the building necessary to add a new system called In-building coverage solution, which is a system with transmitter and receiver devices installed inside that aims to serve the needs of telecommunications in the building in terms of signal quality, coverage and its traffic capacity [8]. LTE advanced pro by utilizing license assisted access (LAA) technology is a technology that uses an unlicensed and licensed spectrum, which is expected an answer to the problem [9]. LTE advanced pro is the latest technology marker approved by 3GPP release 13 to show the next stage in development towards 5G [10]. With LTE advanced pro-technology, it can increase the efficiency of the spectrum and can increase network capacity and data speeds to be higher [11]. For the implementation of LTE Advanced Pro, mobile operators only need to upgrade existing eNodeB devices related to radio interface configuration to provide better cost-effective [12]. Also, it is necessary to have an investment cost analysis for the implementation of the tool, namely, capital expenditure (CAPEX) and operational expenditure (OPEX) [13].

The application of new technology requires a study of various aspects, such as technical aspects and economic aspects in order to measure the efficiency and investment feasibility of implementation [14]. In this study, the planning by the capacity method will use to determine the design of 4G LTE technology and then a techno-economic review is made using the discounted cash flow (DCF) method to measure the feasibility of the costs incurred in implementing the 4G LTE Advanced Pro [15].

2. RESEARCH METHOD

In this study, there are several stages of systematic and structured work established to obtain the expected results. The flow of this research can be known in Figure 1.

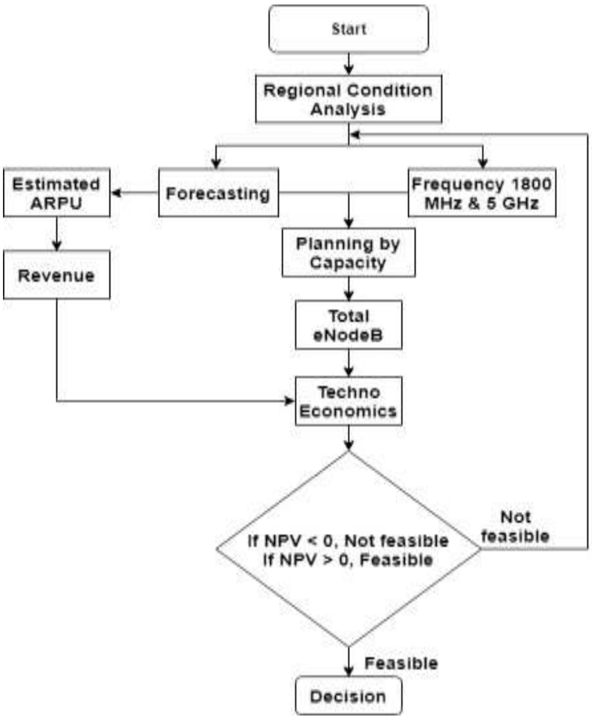

Figure 1. Research flow diagram

2.1. Design analysis in technology

2.1.1. Forecasting Number of LTE Users

Forecasting of the population can calculate by the mathematical method of geometry projection shown in (1) as follows [20].

$$P_t = Po(1 + X\%)^n \tag{1}$$

Where, Pt is the number of population t-year, Jo is the initial population, X% is the rate of population growth, and n is the number of years from 0 to n.

Then to predict the amount of LTE users in the next five years with (2) as follows:

$$P = X\% \text{ x } Pt \tag{2}$$

Where P is the number of cellular users, Pt is the number of population in the t-year, and X% is cellular teledensity (%).

2.1.2. Network throughput

To calculate the value of throughput per session in this study, using standard service model parameters from vendor Huawei [17]. Throughput per session can calculate using (3) as follows:

$$\text{Troughput per session} = \text{PPP}_{\text{session rate}} \text{ x duty ratio x bearer rate x } [\frac{1}{1-\text{BLER}}] \tag{3}$$

Where, throughput per session is a minimum throughput requirement (Kbit), bearer rate is the data rate that must be provided by the service application layer (Kbps), PPP Session rate is the average duration of each service, duty ratio is the ratio of data sent in each session. And BLER is allowed in one session.

Single user throughput (SUT) is the activity of every internet user who is diverse in using LTE services [17]. By using the traffic parameters of the standard model from Huawei, and the standardization peak to average ratio, the value of single-user throughput can be calculated with (4).

$$\text{SUT (IP)} = \frac{\sum(\text{Troughput per session x BHSA x Penetration rate) x (1+Peak to Average Ratio)}}{3600} \tag{4}$$

Where, single-user throughput (IP), BHSA is a service attempt in a busy hour, penetration Rate is the penetration of service usage by area, 3600 is time frame one hour, and Peak to average ratio is Estimated overload on traffic for dense urban peak to average ratio is 40%, urban 20% [17].

Network throughput is the total number of traffic needs in the service area to meet the needs of all users [17]. To calculate network throughput using (5):

$$\text{Network Throughput} = \text{Final user x Single User Throughput} \tag{5}$$

2.1.3. Throughput per cell

Calculating throughput per cell to determine the size of uplink and downlink in a cell. The steps to calculate the uplink and downlink MAC layer throughput, then calculate the average cell throughput based on the average SINR distribution [17]. After that, we can know the value of throughput per cell MAC throughput calculation using (6) and (7) follows:

$$\text{UL MAC Throughput} + \text{CRC} = (\text{NRE} - \text{NrReUL}) \text{ x Code bit x Code rate x Nrb x C x 100} \tag{6}$$

$$\text{DL MAC Throughput} + \text{CRC} = (\text{NRE} - \text{NcRE} - \text{NrRE}) \text{x Code bit x Code rate x Nrb x C x 1000} \tag{7}$$

Where, UL and DL MAC throughput is uplink and downlink MAC layer throughput, CRC is cyclic redundancy check (24 bits), NRE is the number of resistor elements (RE) in 1 ms (168), NcRE is the number of control channels resistor elements in 1 ms (36), NrRE is the number of reference signals resistor elements in 1 ms (12), NrReUL is the number of reference signals resistor elements in 1 ms in the uplink (24), Code bits are modulation efficiency, code rate is channel coding rate, Nrb is the number of block resource to be used, and C is the MIMO antenna model.

Calculate the value of cell average throughput using (8) based on parameters from the average SINR distribution.

$$\text{Cell average throughput (MAC)} = \sum_{n-1}^{n-8} \text{Pn x Rn} \tag{8}$$

Where n is the number of cell throughput, Pn is SINR Probability, and Rn is Uplink / Downlink cell throughput.

The amount of the throughput per cell will be calculated by converting the cell layer throughput (MAC) to the IP layer. This conversion process will use relative efficiency radio overhead [17]. Then the throughput per cell (IP) can be determined by the (9).

$$\text{Throughput per cell (IP)} = \text{Cell average throughput (MAC) x Relative efficiency} \tag{9}$$

Where relative efficiency is the parameter multiplication of radio over head with the parameter values as follows [18]; symbol A = 0.993377, B = 0.993421, and C = 0.993464.

2.1.4. The number of cells and eNodeB

The next is to count the number of uplink and downlink cells. By using (10) and (11) the following formula calculates the number of cells and number of eNodeB:

$$\text{Number of cell} = \frac{\text{Network throughput}}{\text{Throughput per cell}} \tag{10}$$

$$\text{Number of eNodeB} = \frac{\text{Number of cell}}{\text{Number of cell per site}} \tag{11}$$

2.2. Economic analysis

Economic analysis is the next stage after design analysis in technology. For the techno-economic scheme, several parameters that influence it include the final number of eNodeB, number of customers, revenue value, CAPEX and OPEX costs to find out the NPV, IRR, and Payback period [18]. While the assumptions of parameters from the economic scenario obtained Telkomsel's market share of 50%, 35% of traffic penetration [19]. And for the minimum attractive rate of return (MARR) value is 9%, assuming that the margin due to risk is 3% plus the Bank Indonesia interest rate in 2019 of 6% [20].

2.2.1. Average revenue per user

Average revenue per user (ARPU) is a measure to find out the average amount of income obtained by telecommunications companies from consumers. To calculate the ARPU value, first, calculate the ARPU growth every year [24]. To calculate ARPU growth using the calculate compound annual growth (CAGR) formula as in (12), which is used to calculate ARPU growth [22].

$$\text{CAGR} = \left(\frac{\text{Initial value}}{\text{The last value}}\right)^{1/\text{n}} - 1 \tag{12}$$

Where n is the number of years.

After getting ARPU growth, the next step is to calculate the number of ARPU with (13).

$$\text{ARPU} = (1 + \text{Cgrowth})\text{x ARPU n} - 1 \tag{13}$$

Where (1+Cgrowth) is the percentage of growth/decline, ARPU n-1 is the ARPU of the previous year.

2.2.2. Revenue

Revenue is a profit that is obtained by the company, but not from investment results within a specified period [21]. With use (14) the revenue value can calculate.

$$\text{Revenue} = \text{Number of customers x ARPU} \tag{14}$$

2.2.3. Net present value

The net present value (NPV) is a widely used model in measuring the feasibility of a project, which takes into account the overall cash flow pattern of investment, about to time, based on a specific discount rate [23]. Where the value of cash flow from the previous period, the profit and loss is taken from the 2018 and 2017 annual reports. To calculate the NPV value using the (15) follows.

$$\text{NPV} = \sum_{t=1}^{n} \frac{\text{CFt}}{(1+i)^t} \tag{15}$$

Where CFt is the annual cash flow in the period t, i is the interest rate, Co is the initial investment in the zero year, n is the number of years, and t is the t-year.

2.2.4. Internal rate of return

Internal rate of return (IRR) is an investment calculation method according to the interest rate that equates the present value of the future proceeds with the current value of net cash receipts in the future [17]. The following (16) is a formula for calculating IRR values.

$$\mathrm{Co} = \sum_{t=0}^{n} \frac{\mathrm{CFt}}{(1+\mathrm{IRR})^{t}} \qquad (16)$$

Where, Co is the initial investment in the zero year, n is the number of years, and t is the t year.

2.2.5. Payback period

Payback period (PBP) is a method of evaluating the feasibility of investment that can return within a period [25]. By using (17), the following that how long an investment can return:

$$\text{Payback Period} = \sum_{t=1}^{T} \frac{\mathrm{CCFt}}{(1+r)^{t}} \qquad (17)$$

Where, T is time, r is discount rate and for payback period estimation r was zero.

3. RESULTS AND ANALYSIS

3.1. LTE planning by capacity

Capacity by planning is a method for determining network scale based on capacity requirements, capacity planning used to determine the features of different regions and bandwidths. Central Jakarta has the characteristics of urban and urban dense areas [16]. According to its characteristics, central Jakarta divided into two types of urban and urban dense areas with a total productive age of central Jakarta in 2019 for urban area types is 145218 people and for urban dense totalling 687465 people [16].

At this stage, the number of LTE users will calculate for the next five years. With this data, an LTE Advanced pro network will plan. With the results of calculations for the type of dense urban areas and urban LTE users in 2023 totaled 127134 people and 26855 people. After knowing the forecasting of the number of subscribers for 5 years, then calculating the Network throughput, the first step is to find the value of throughput per session as in Table 1.

Table 1. Throughput per session for service model traffic [12]

Traffic Parameters	Uplink				Downlink				Uplink	Downlink
	Bearer Rate (Kbps)	PPP Session Time (s)	PPP Session Duty Ratio	BL ER	Bearer Rate (Kbps)	PPP Sesion Time (s)	PPP Session Duty Ratio	BL ER	Throughput /Session (Kbit)	Throughput /Session (Kbit)
VoIP	26.90	80	0.4	0.01	26.9	80	0.4	0.01	869.49	869.49
Video Phone	62.53	70	1	0.01	62.53	70	1	0.01	4421.31	4421.31
Video Conference	62.53	1800	1	0.01	62.53	1800	1	0.01	113690.9	113690.91
Real Time Gaming	31.26	1800	0.2	0.01	125.06	1800	0.4	0.01	11367.27	90952.73
Streaming Media	31.26	3600	0.05	0.01	250.11	3600	0.95	0.01	5683.64	864016.36
IMS Signalling	15.63	7	0.2	0.01	15.63	7	0.2	0.01	22.1	22.1
Web Browsing	62.53	1800	0.05	0.01	250.11	1800	0.05	0.01	5684.55	22737.27
File Transfer	140.69	600	1	0.01	750.34	600	1	0.01	85266.67	454751.51
Email	140.69	50	1	0.01	750.34	15	1	0.01	7105.56	11368.79
P2P File Sharing	250.1	1200	1	0.01	750.34	1200	1	0.01	303151.51	909503.1

Then calculating the single-user throughput that refers to the traffic model parameters as in Table 2 using (4), the value of throughput per session is calculated based on each endpoint. The value of network throughput is in accordance with (5), the results of network throughput calculations are shown in Table 3.

To calculate the capacity of uplink and downlink cells refers to the average SINR distribution parameter for 1800 MHz frequency and frequency of 5 GHz, using four bandwidths of 20 MHz (Nbr = 100), 15 MHz (Nbr = 75) 10 MHz (Nbr = 50), and 5 MHz (Nbr = 25), with a bandwidth of 20 MHz (Nbr = 100), using (6) and (7) with the following calculation results in Table 4 and Table 5. By using (8) and SINR parameters in the SINR average distribution table, the average cell throughput value can determine. Table 6 follows the amount of cell average throughput calculated.

Table 2. Single user throughput [12]

User Behavor	Dense Urban		Single User Throughput		Urban		Single User Throughput	
	Penetration Ratio	BH SA	Uplink	Downlink	Penetration Ratio	BH SA	Uplink	Downlink
VoIP	100 %	1.4	1704.21	1704.21	100%	1.3	1356.412	1356.412
Video Phone	20%	0.2	247.5935	247.5935	20%	0.16	169.778	169.7784
Video Conference	20%	0.2	6366691	6366.691	15%	0.15	3069.655	3069.655
Real Time Gaming	30%	0.2	954.8509	7640.029	20%	0.2	545.629	4365.731
Streaming Media	15%	0.2	238.7127	36288.69	15%	0.15	153.458	23328.44
IMS Signalling	40%	5	61.88848	61.88848	30%	4	31.8283	31.8283
Web Browsing	100%	0.6	4775.018	19099.31	100%	0.4	2728.582	10913.89
File Trnsfer	20%	0.3	7162.4	38199.13	20%	0.2	4092.8	21828.07
Email	10%	0.4	397.9111	636.6521	10%	0.3	255.8	409.276
P2P File Sharing	20%	0.2	16976.48	50932.17	20%	0.3	21826.91	65484.22
Single User Throughput in Busy Hours			1373.25	5691.94			255.12	976.9

Table 3. Network throughput

No	Regional Type	Network Throughput (Mbps)	
		Uplink	Downlink
1	Dense Urban	1373.25	5691.94
2	Urban	255.12	976.9

Table 4. Results of calculating 1800 MHz cell capacity

No	Modulation Coding Scheme	UL MAC Layer Throughput (Mbps)	DL MAC Layer Throughput (Mbps)
1	QPSK 1/3	19.008	15.84
2	QPSK ½	28.8	24
3	QPSK 2/3	38.592	32.16
4	16QAM ½	57.6	48
5	16QAM 2/3	77.184	64.32
6	16QAM 4/5	92.16	76.8
7	64QAM ½	86.4	72
8	64QAM 2/3	115.776	96.48

Table 5. Results of calculation of 5 GHz cell capacity

No	Modulation Coding Scheme	Bandwidth 20 MHz MAC Throughput (Mbps)		Bandwidth 15 MHz MAC Throughput (Mbps)		Bandwidth 10 MHz MAC Throughput (Mbps)		Bandwidth 5 MHz MAC Throughput (Mbps)	
		Uplink	Downlink	Uplink	Downlink	Uplink	Downlink	Uplink	Downlink
1	QPSK 1/3	19.008	17.424	14.25	13.068	9.504	8.712	4.752	4.356
2	QPSK ½	28.8	26.4	21.6	19.8	14.4	13.2	7.2	6.6
3	QPSK 2/3	38.592	35.376	28.944	26.532	19.296	17.688	9.648	8.844
4	16QAM ½	57.6	52.8	43.2	39.6	28.8	26.4	14.4	13.2
5	16QAM 2/3	77.184	70.752	57.888	53.064	38.592	35.376	19.296	17.688
6	16QAM 4/5	92.16	84.48	69.12	63.36	46.08	42.24	23.04	21.12
7	64QAM ½	86.4	79.2	64.8	59.4	43.2	39.6	21.6	19.8
8	64QAM 2/3	115.776	106.128	86.832	79.596	57.888	53.064	28.944	26.532

Table 6. Cell average throughput

No	Frequency	Uplink Cell Average Throughput (MAC)	Downlink Cell Average Throughput (MAC)
1	1800 MHz dengan bandwidth 20 MHz	61.246	51.1
2	5 GHz dengan bandwidth 20 MHz	50.451	46.247
3	5 GHz dengan bandwidth 15 MHz	37.837	34.685
4	5 GHz dengan bandwidth 10 MHz	24.731	22.671
5	5 GHz dengan bandwidth 5 MHz	12.613	11.562

After the value of the cell average throughput (MAC) is converted to the IP layer throughput. By using (9) throughput per cell can be known, as in Table 7. By (10), we can find out the number of cell carrier aggregation 1800 MHz with a bandwidth of 20 MHz and 5 GHz frequency with a bandwidth of 20 MHz, 15 MHz, 10 MHz, and 5 MHz. The results of cell capacity calculations from downlink and uplink are listed in Table 8.

Referring to the results of the calculation of the number of cells that have obtained as in Table 8, the estimate of the number of eNodeB will be used (11). Then the calculation results are as in Table 9. From the number of eNodeB obtained from the calculation, the highest number of eNodeB is chosen, which is the total value of eNodeB [16].

Table 7. Cell capacity for every frequency

Frequency	Throughput per cell	
	Uplink	Downlink
1800 MHz & 5 GHz	109.51	95.44
1800 MHz & 5 GHz	97.14	84.11
1800 MHz & 5 GHz	84.78	72.77
1800 MHz & 5 GHz	72.41	61.43

Table 8. Number of cells carrier aggregation 1800 MHz & 5 GHz

Regional Type	LTE Users	Network Thoroughput (Mbps)		Bandwidth of 20 & 20 MHz		Bandwidth of 20 & 15 MHz		Bandwidth of 20 & 10 MHz		Bandwidth of 20 & 5 MHz	
		UL	DL	UL	DL	UL	DL	UL	DL	UL	DL
Dense Urban	127134	1373.3	5684.5	13	60	14	68	16	78	19	93
Urban	26855	244.3	934.7	2	10	3	11	3	13	4	15
Total	147338	1564.2	6373.6	15	70	17	79	19	91	23	108

Table 9. Number of eNodeB carrier aggregation 1800 MHz & 5 GHz

Regional Type	LTE Users	Network Thoroughput (Mbps)		Bandwidth of 20 & 20 MHz		Bandwidth of 20 & 15 MHz		Bandwidth of 20 & 10 MHz		Bandwidth of 20 & 5 MHz	
		UL	DL	UL	DL	UL	DL	UL	DL	UL	DL
Total eNodeB	147338	1564.2	6373.6	5	23	6	27	6	30	7	36

3.2. Techno economic analysis

The discounted cash flow (DCF) method was chosen because it will provide an overall overview to identify inputs in the form of cost structures (CAPEX, OPEX, and Revenue) and on the output parameters, namely IRR, NPV, and PBP [26].

3.2.1. Capital expenditure

Each table has a quantity of eNodeB so, it has a different investment value, as in Table 10 is the Assumption of Initial Capital Expenditure, the following scenario simulation used:

Table 10. Assumption of initial capital expenditure for scenario

Equipment	Price (USD)	Scenario 1	Scenario II	Scenario III	Scenario IV
Upgrade eNodeB	$22,105.8	36	30	27	23
CME LTE	$1750	36	30	27	23
Installation & Commisioning	$5,333.4	36	30	27	23
Device LTE	$33,609.4	36	30	27	23
Maintenance	1.5% total cost	1	1	1	1
Total initial investment		$2,477,417.79	$2,100,624.21	$1,912,227.42	$1,661,031.7

3.2.2. Operational expenditure

Operational expenditure (OPEX) is an allocation of operating and maintenance expenses needed in operating an LTE network, the value is as shown in Table 11.

Table 11. Estimated cost of OPEX LTE advanced pro

Years	Marketing	General and Administration	Human Resources	Oprational & Maintenance	Total OPEX
2019	2143.35	7125.22	76987.53	144690.15	250178.55
2020	45797.36	15265.79	80729.13	3976.29	145768.57
2021	88450.79	29483.60	98601.00	8161.86	395947.12
2022	166185.92	55395.31	103393.00	14230.93	339205.16
2023	265455.92	88485.31	108417.90	40343.35	502702.48

3.2.3. Average revenue per user

Using (12) and (13) with ARPU values in 2019, then the ARPU value can be known. Table 12 is the result of the ARPU calculation up to 2023.

Table 12. ARPU value

ARPU Data For the Period 2019 to 2023					
Years	2019	2020	2021	2022	2023
Blended ARPU	46000	46644	47297	47959	48630

3.2.4. Revenue

By using the ARPU value in Table 12 with the number of Telkomsel LTE subscribers, the revenue value can known. Following is Table 13 of the calculation results of (14).

Table 13. Revenue LTE advanced pro

Years	Predicted Number of LTE Customers	Predicted ARPU	Revenue ($)
2019	135218	46.000	453470.27
2020	136719	46.644	464923.12
2021	138237	47.297	476666.22
2022	139771	47.959	488701.50
2023	153989	48.630	545946.94

3.2.5. Techno-economic feasibility

Discounted cash flow (DCF) based on DCF calculations to determine the internal rate of return (IRR) output, Payback period (PBP), and net present value (NPV). If the NPV value > 0, then the implementation of LTE Advanced Pro is feasible because the company gets a benefit. If NPV = 0, the company will not get any loss or profit. And if NPV <0, then the implementation of LTE Advanced Pro is not feasible because the company will not be able to profit. From the above data Table 14, NPV, IRR, and PBP can be calculated by (15), (16), and (17). The following Table 15 is the result of a techno-economic feasibility analysis:

Table 14. Investment value and net cash

	First Investment	Second Investment	Third Investment	Fourth Investment	Net Cash Flow ($)
0 Years	$2,477,417.79	$2,100,624.21	$1,912,227.42	$1,661,031.7	
1st year					$453,470.27
2nd year					$476,143.78
3rd year					$499,950.97
4th year					$524,948.52
5th year					$551,195.95

Table 15. Economic feasibility analysis of NPV, IRR, and PBP

Scenario	NPV	IRR	PBP	Summary
Scenario I	-$318,035.6 NPV<0	0.37% < MARR 9%	4 years 9 months	Not feasible because NPV<0
Scenario II	$58,758.02 NPV>0	5.97% < MARR 9%	4 years 2 months	Not feasible because IRR 9% >5.97%
Scenario III	$247,154.81 NPV>0	9.40% > MARR 9%	3 years 9 months	feasible
Scenario IV	$498,350.53 NPV>0	14.91% > MARR 9%	3 years 4 months	feasible

4. CONCLUSION

Based on the results of the analysis presented in the previous chapters, conclusions can draw regarding the technological and techno-economic review of the implementation of the LTE advanced pro network in Jakarta. For the third scenario the number of eNodeB used is 27 sites, for analysis of discounted cash flow with an initial investment of $1,912,227.42, NPV is $247,154.81 NPV> 0, IRR value of 9.40%> MARR of 9% while for payback period for three years and nine-month of the results of the third scenario is feasible to be implemented. Whereas for the fourth scenario the number of eNodeB used is 23 sites, for the analysis of discounted cash flow with an initial investment of $1,661,031.7 NPV value of $498,350.53 NPV > 0, for an IRR value of 14.91%> MARR of 9%. While the payback period was three years and four months, then the fourth scenario is declared to be eligible to be implemented. With this result, the implementation of LTE Advanced pro in central Jakarta is said to be feasible.

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