Microwave License Fee for 5G Backhaul Connectivity (Study Case: Indonesia)

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ABSTRACT

Frequency is an unrenewable natural resource. Therefore, its usage must be regulated so new technology like 5G still gets frequency allocation. The 28 GHz frequency is an option that can be used in Indonesia for 5G because it gets a large bandwidth allocation, namely 112 MHz. For frequency to be used efficiently, one of the efforts is using frequency license fees. The frequency license fee in Indonesia is regulated in MoCI regulation no. 17 of 2005 and 7 of 2021 regarding BHP ISR for microwave link services. However, prices applied in Indonesia for 5G backhaul frequencies must be higher than in other countries such as India and Australia. With similar conditions, India applies Rp. 771,207,014, Australia Rp. 142,318,583, while Indonesia applies Rp. 32,949,287 for the frequency license fee. Based on calculations, simulations, and changes to the components of the BHP ISR formula results using the Top-down approach, it increases the frequency license fee to Rp. 81,320,400, which experienced an increase of 146%. The new price obtained is still below that of other countries because other countries have a larger GDP than Indonesia. This new price is expected to make frequency usage more efficient and increase state income.

1. Introduction

Frequency is one of the natural resources that humans cannot renew. Along with technology development, especially in telecommunication, frequency use must be regulated as efficiently as possible. So that future technologies will still receive frequency allocation (Pramono & Mahoro, 2019). One of the emerging new technologies, 5G technology, is one of the technologies that need frequency allocation. One of the key 5 G features is high-speed connectivity and high concurrent connected devices, which require high bandwidth on their access networks and backbone networks to support 5G operation (Barb & Otesteanu, 2020). Surveys that Ericsson has conducted resulted in the growth of the number of mobile network users from 2015 to 2020. Figure 1 shows the numbers of mobile network users each year from 2015 – 2020.

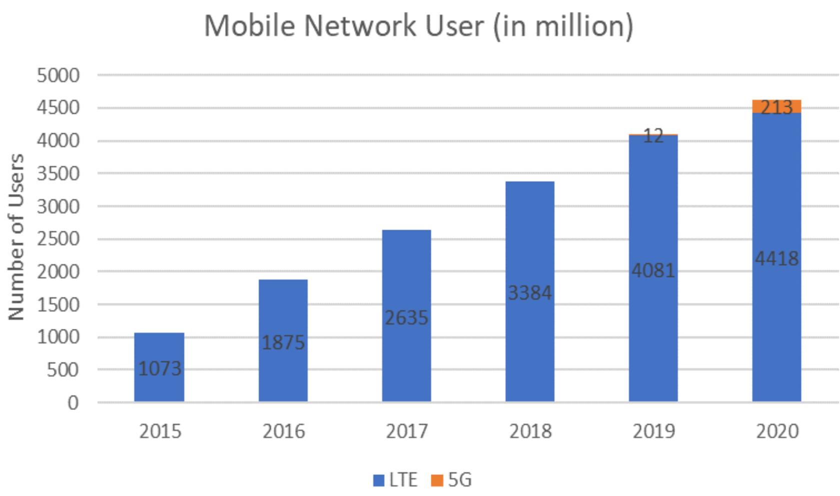


Figure 1. Mobile Network Users Growth 2015 – 2020. (Ericsson, 2020)

Ideally, the first choice for a 5G backhaul is Fiber Optic (F.O.). However, using F.O. to connect all Base Transceiver Stations (BTS) or, more specifically, small cells in 5G is considerably more complex due to obstacles, deployment costs, and time to deploy (Ahamed & Faruque, 2018). This technological development causes microwave links to be considered as an alternative for 5G wireless backhaul by using higher frequencies that offer more considerable bandwidth, such as the mmWave frequency. The frequency license fee can be applied to ensure that frequency is used as efficiently as possible (ITU-R, 2018).

The frequency license fee that is already applied in Indonesia for microwave links is called the “Biaya Hak Penggunaan Izin Stasiun Radio (BHP ISR)” or ISR license fee, which has been regulated in the Ministry of Communication and Informatics (MoCI) regulation number 17 of 2005 (Tata Cara Perizinan Dan Ketentuan Operasional Penggunaan Spektrum Frekuensi Radio, 2005) and regulated on newer regulation which is the MoCI regulation number 7 of 2021 (Penggunaan Spektrum Frekuensi Radio). Even though there is a new legal basis for the BHP ISR, there isn’t any change in the formula and its components; therefore, the calculation results are still the same. Frequency segmentation that applies in Indonesia, according to Government Regulation number 28 of 2005, still focuses on low frequencies, namely 9 kHz to 3000 MHz. However, Indonesia has begun to allocate the use of the 3 GHz – 86 GHz frequency and its bandwidth allocation in MoCI regulation number 2 of 2019 (Setiawan, 2010).

Compared to peer country, Indonesia’s license fee is far below the average price (Australian Communications and Media Authority, 2021; Doorsanchar et al., 2014). It is feared that license fees that are too low can make the usage of frequency become less efficient. The ISR license fee which was released in 2005 hasn’t been reviewed since it was released. From 2005 till now, technology development has made several breakthroughs such as 4G deployment, and currently in process to deploy the 5G technology.

2. Literature review

2.1. License Fee in Indonesia

The frequency spectrum license fee that applies in Indonesia is divided into two, namely the license fee, which is determined based on the frequency band used or Izin Pita Frekuensi Radio (IPFR) license fee, used for cellular only and the license fee, which is determined based on the number of radio stations used or Izin Stasiun Radio (ISR) license fee that used for another service than cellular such as microwave link (Peraturan Pemerintah No. 80 Tahun 2015, 2015; Peraturan Pemerintah Republik Indonesia Nomor 28 Tahun 2005, 2005).

The ISR license fee is a non-tax state income for frequency usage that telecommunications operators must pay to use the frequency legally regulated on said license. ISR license fee was formalized in MoCI regulation number 19 of 2005 and Governmental regulation number 28 of 2005. The following is the ISR license fee formula (Peraturan Pemerintah Republik Indonesia Nomor 28 Tahun 2005, 2005).

$$BHP\ Frekuensi\ (Rupiah) = \frac{(Ib \times HDLP \ \times b) + (Ip \times HDDP \times p)}{2} \qquad \text{1)}$$

Where:

HDDP : Harga Dasar Daya Pancar / Transmits Power Base Price
HDLP : Harga Dasar Lebar Pita / Bandwidth Base Price
Ib : Indeks Biaya Pendudukan Lebar Pita
Ip : Indeks Biaya Daya Pemancaran Frekuensi

The values of Ib and Ip for the frequencies used for microwave link point-to-point networks are 0.06 for Ib and 0.29 for Ip. The value of HDLP and HDDP depends on the zoning. The division of frequency usage zoning is regulated in MoCI regulation number 19 of 2005. Meanwhile, the list of HDLP and HDDP is held in Government Regulation number 28 of 2005 (Peraturan Pemerintah Republik Indonesia Nomor 28 Tahun 2005, 2005). Tables 1 to 2 show the HDLP and HDDP lists, respectively.

Table 1. HDLP on ISR Spectrum License Fee.

Frequency Segmentation		HDLP (Rp/kHz)				
Frequency Band	**Frequency Range**	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**
VLF	9 – 30 kHz	20,961	16,769	12,576	8,384	4,192
LF	30 – 300 kHz	15,715	12,572	9,429	6,286	3,143
MF	300 – 3000 kHz	15,249	12,199	9,149	6,099	3,050
HF	3 – 30 MHz	14,581	11,665	8,749	5,832	2,916
VHF	30 – 300 MHz	12,888	10,310	7,733	5,155	2,578
UHF	300 – 3000 MHz	11,772	9,418	7,063	4,709	2,354
SHF	3 – 30 GHz	9,681	7,745	5,809	3,873	1,936
EHF	30 – 275 GHz	6,101	4,881	3,661	2,440	1,220

Source: (Peraturan Pemerintah No. 80 Tahun 2015, 2015)

Table 2. HDDP on ISR Spectrum License Fee.

Frequency Segmentation		HDDP (Rp/dBm)				
Frequency Band	**Frequency Range**	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**
VLF	9 – 30 kHz	191,629	153,303	114,977	76,652	38,326
LF	30 – 300 kHz	142,844	114,275	85,707	57,138	28,569
MF	300 – 3000 kHz	140,403	112,322	84,242	56,161	28,081
HF	3 – 30 MHz	135,353	108,282	81,212	54,141	27,071
VHF	30 – 300 MHz	119,665	95,732	71,799	47,866	23,933
UHF	300 – 3000 MHz	109,481	87,585	65,688	43,792	21,896
SHF	3 – 30 GHz	89,364	71,491	53,618	35,745	17,873
EHF	30 – 275 GHz	54,188	43,350	32,513	21,675	10,838

Source: (Peraturan Pemerintah No. 80 Tahun 2015, 2015)

2.2. Microwave Link

Microwave link technology is a wireless communication technology that uses high frequency as a medium for sending data between base stations (Hikmaturokhman et al., 2017). In Indonesia, microwave links have 15 radio frequency bands designated. This radio frequency band is regulated by MoCI regulation number 33 of 2015. Table 3 – 4 shows the frequency bands and minimal distance per band frequency, respectively.

Table 3. Microwave Link Frequency Band Allocation in Indonesia.

No.	Frequency Bands (MHz)	Bandwidth
1.	4,400 – 5,000	40 MHz
2.	6,425 – 7,110	40 MHz
3.	7,125 – 7,425	7 MHz; 14 MHz
4.	7,425 – 7,725	7 MHz; 14 MHz; 28 MHz
5.	7,725 – 8,275	29.65 MHz
6.	8,275 – 8,500	28 MHz
7.	10,700 – 11,700	40 MHz
8.	12,750 – 13,250	7 MHz; 14 MHz; 28 MHz
9.	14,400 – 15,350	7 MHz; 14 MHz; 28 MHz
10.	17,700 – 19,700	7 MHz
11.	21,200 – 23,600	7 MHz; 14 MHz; 28 MHz; 112 MHz
12.	27,500 – 29,500	14 MHz; 28 MHz; 56 MHz; 112 MHz
13.	31,800 – 33,400	14 MHz; 28 MHz; 56 MHz; 112 MHz
14.	37,000 – 39,500	14 MHz; 28 MHz; 56 MHz; 112 MHz
15.	71,000 – 76,000	125 MHz; 250 MHz; 500 MHz; 1 GHz

Source: (Peraturan Menteri Kominfo No. 33 Tahun 2015, 2015)

Table 4. Reference Distance Microwave Link Radio Station.

Radio Frequency Bands (GHz)	Distance (km)
4 / 6	> 20
7 / 8	>8

11 / 13 / 15	>2.5
18 / 23 / 28	>1
32 / 38 / 70 / 80	>0

Source: (Peraturan Menteri Kominfo No. 33 Tahun 2015, 2015)

2.3. 5G Backhaul and Fronthaul

Mobile Backhaul is a transport network that connects the core network with the Radio Access Network (RAN). Meanwhile, the fronthaul combines the baseband with the remote radio head (RRH) (Gomes et al., 2015). Figure 2 illustrates the backhaul and front haul of 5G.

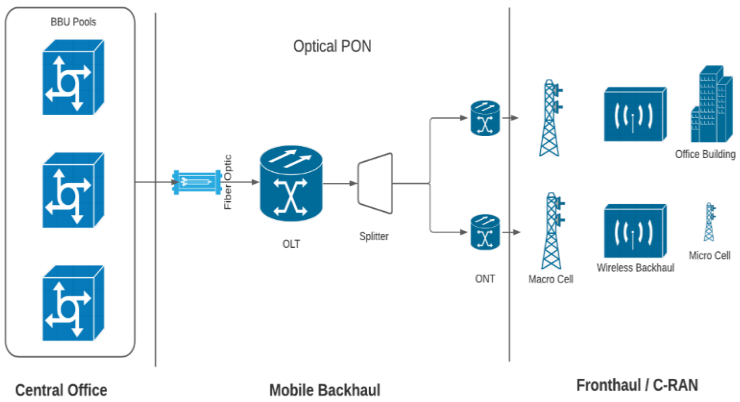


Figure 2. 5G Fronthaul and Backhaul Illustration (Haddaji et al., 2018).

The development of mobile technology has led to a rapid growth in the number of devices. This large number of devices means that RAN on 5G must be able to make backhaul and fronthaul handle data floods that can cause the growth of the number of base stations or access points with much smaller coverage or, often referred to as mobile network densification (Pérez & Lessmann, 2015). One of the efforts made to reduce costs while still increasing the number of base stations or access points is for operators to use small cell or micro cell technology, which has a very high density and is connected using a wireless backhaul using mmWave (Haddaji et al., 2018; Jaber et al., 2016; Lun, 2017).

2.4. Initial 5G Market Forecast

To know the demand for 5G technology, it is necessary to make an initial forecast using the Bass Diffusion Model, with the purchase probability at the time being the main assumption. So, the bass model is suitable for forecasting early users of 5G. This 5G user forecast will provide insight for new users of 5G and its growth so that 5G demand will be seen in Indonesia. The bass diffusion model can be calculated using the following formula (Adi Kusuma & Suryanegara, 2019).

$$N(t) = M\frac{1-e^{-t(p+q)}}{1+\frac{q}{p}e^{-t(p+q)}} \quad \text{..........} \quad 2)$$

Where:

N(t) : Number of customers in year t

M : Potential Market

p : Adoption Rate of innovator agent or adoption rate by agent influenced by advertisement

q : Adoption rate of Imitator agent or adoption rate by imitator agent that influenced by internal pressure of the system.

2.5. 5G Coverage Planning

Several parameters, such as path loss, link budget, and the propagation model used, influence coverage planning in 5G. The propagation model used in 5G coverage planning in this study is Urban Micro (UMi), which refers to 3GPP 38.901. The UMi propagation model is used to carry out Outdoor to Outdoor (O2O) and Outdoor Indoor (O2I) planning with a user terminal height (hUT) between 1.5 m and 22.5 m and a base station height (hBS) of 10 m. The UMi propagation model is calculated to obtain the distance between the base station and the user terminal. The following formulas are the formulas to calculate thermal noise, sub-carrier quantity, path loss, and UMi propagation, respectively (TSGR, 2017).

$$Thermal\ Noise = 10\log_{10}(k \times T \times B) \quad \ldots\ 3)$$

Where:

K : Boltzman Constant (1.38 x 10^{-20})
T : Temperature (293° Kelvin)
B : Bandwidth (MHz)

$$SCQ = RB \times Subcarrier\ Per\ Resource\ Block \quad \ldots\ 4)$$

Where:

Resource Block : 132
Subcarrier per Resource Block : 12

$$Pathloss\ (dBm) = Power\ Transmit - 10\log_{10}(SCQ) + Antenna\ Gain - Cable\ loss - Penetration\ Loss - Foliage\ Loss - Body\ Block\ loss - Interference\ Margin - rain\ or\ ice\ margin - slow\ fading\ margin - UT\ antenna\ gain - thermal\ noise\ figure - UT\ noise\ figure - demodulation\ threshold\ SINR \quad \ldots\ 5)$$

$$PL_{UMi} = 32.4 + 21\log_{10}(d_{3D}) + 20\log_{10}(fc) \quad \ldots\ 6)$$

Where:

d_{3D} : Distance between base station and user terminal
fc : Frequency

$$d_{2D} = \sqrt{(d_{3D})^2 - (h_{BS} - h_{UT})^2} \quad \ldots\ 7)$$

$$Coverage\ area = 2.6 \times (d_{2D})^2 \quad \ldots\ 8)$$

Where:

d_{3D} : Distance between base station and user terminal
h_{BS} : Base station height (m)
h_{UT} : User terminal height (m)
d_{2D} : Cell radius

The parameter to calculate formula 4 – 6 is by using the data provided on table 5. After the distance between base station and user terminal is obtained, the following formulas can be used to calculate base station coverage.

Table 5. 5G Coverage Planning Parameter.

Parameter	Uplink	Downlink
Power Transmit	23	32.5
Resource Block	132	132
Subcarrier per RB	12	12
SCQ	1584	1584
Antenna Gain (dBi)	2	2
Cable Loss (dBi)	0	0
Penetration Loss (dB)	12.23	12.23
Foliage Loss (dB)	5	5
Body block loss (dB)	15	15
Interference Margin (dB)	0.5	1
Rain / Ice Margin (dB)	3	3
Slow Fading Margin (dB)	7	7
UT Antenna Gain (dB)	Omni	

Bandwidth (MHz)	112	112
Konstanta Boltzman (mWs/K)	1.38E-20	1.38E-20
Temperature (Kelvin)	293	293
Thermal Noise power (dBm)	-153.440353	-150.44
UT Noise Figure (dB)	7	7
Demodulation Threshold SINR (dB)	-1.1	-1.1
Base Station Height (m)	22.5	22.5
Receiver Height (m)	1.5	1.5

Source: (Nashiruddin et al., 2021)

2.6. 5G Capacity Planning

Capacity planning is carried out to determine the number of access points or base stations based on traffic requirements. To select traffic needs, it is necessary to forecast the number of subscribers first by using the bass diffusion model. The following formula can predict traffic demand based on the forecasted subscribers (Adi Kusuma & Suryanegara, 2019).

$$G(t) = \rho \times \frac{8}{N_{dh} \times N_{md}} \times \varphi(t) \times D_k \quad \text{....... 9)}$$

Where:

G(t) : Traffic demand

ρ : User density

N_{dh} : Number of busy hours per day

N_{md} : Number of days per month

φ(t) : Percentage of active users

D_k : Average demand per month

The data for user density on traffic demand formula will be based on the forecasted subscribers. Busy hours are assumed to be 9 hours a day, 30 days a month, 100% active users, and 100 GB per user demand. This assumption is based on the general working hours applied in Indonesia. The logic of this assumption is that the nine working hours generated the peak traffic demand with 100% active users, meaning that any traffic outside the nine working hours will be accommodated. 100 GB per user demand is assumed based on the services that require high data traffic, such as Ultra High Definition (UHD) video streaming, cloud services, online gaming, etc. (Adi Kusuma & Suryanegara, 2019). Each base station's capacity can be calculated using the data from Table 6 and the following formula (Adi Kusuma & Suryanegara, 2019).

$$Throughput\ (Mbps) = 10^{-6} \times \sum_{J=1}^{J} [V_{Layers}^{(j)} \times Q_m^{(j)} \times f^{(j)} \times R_{max} \times \frac{N_{PRB}^{BW(j),\mu}}{T_s^{\mu}} \times 12 \times (1 - OH^{(j)})] \quad \text{....... 10)}$$

Table 6. Base Station Throughput Parameters.

Parameters	Value
J (component carriers)	1
v layers (max MIMO layers)	8
Qm (Modulation order)	8
f (scalling factor)	1
Rmax	0.92578125
NBW PRB (Max number of PRB)	66
T_s^{μ} (OFDM Symbol)	0.000008929
μ (Numerology)	3
Bandwidth	112 MHz
OHj (Overhead for control channels)	0.18

Source: (Nashiruddin et al., 2021; Sabila Putri et al., 2022)

2.7. Benchmark Countries

Countries that are used as benchmarks in this research are India and Australia. The reason for choosing India and Australia is the similarity in climate, and it is still considered one of the neighboring countries with Indonesia. From an economic aspect, India is one of the top 5 countries with the highest Gross Domestic Product (GDP), while Australia is the 14th and Indonesia is the 16th (Forbes India, 2023). On the same condition, which is the 28 GHz with 112 MHz bandwidth, table 7 shows the license fee difference between Indonesia, India, and Australia. Table 7 shows that the license fee applied in Indonesia is far below that of other countries. The difference between Indonesian and Australian license fees is more than double the price, let alone India. License fees that are too low are feared to make the frequency usage less efficient.

Table 7. License Fee Comparison between Indonesia and Benchmark Countries.

Countries	License Fee / radio station	License Fee For 100 radio stations
India	Rp. 771,207,014	Rp. 77,120,701,360
Australia	Rp. 142,318,583.90	Rp. 14,231,858,390.40
Indonesia	Rp. 32,949,287.85	Rp. 3,294,928,785

Source: (Australian Communications and Media Authority, 2021; Doorsanchar et al., 2014)

2.8. Operating Expenses Ratio

Operating Expenses Ratio (OER) is a tool to determine how much operational expense a company incurs. All OER components mentioned in Formula 10 can usually be obtained from a company's annual report or financial statement. Lower OER is better, but the ideal OER is around 60% to 80% (Hayes & James, 2020; Sapuan et al., 2021; Syafrizal et al., 2018).

$$OER = \frac{Total\ Operating\ Expenses - Depreciation}{Gross\ Revenue} \times 100\% \quad \ldots\ldots 11)$$

2.9. Financial Data of Cellular Company

Companies that reviewed on this research are PT. Indosat, Tbk., PT. Telkom Indonesia, Tbk., PT. XL Axiata, Tbk., and PT. Smartfren Telecom, Tbk. Table 8 shows each company OER and ISR license fee paid in 2021 obtained from each company's financial report and annual report.

Table 8. Cellular Company Financial Condition

Components	PT. Indosat, Tbk.	PT. Telkom Indonesia, Tbk.	PT. XL Axiata, Tbk.	PT. Smartfren, Tbk.
Annual License Fee	Rp 425.799.817.374	Rp 615.232.956.512	Rp 400.708.985.285	Rp 188.129.349.693
OER	34,50%	47,12%	47,87%	60,79%

Source: (PT. Indosat Tbk., 2021; PT. Smartfren Telecom Tbk., 2021; PT. Telkom Indonesia Tbk., 2021; PT. XL Axiata Tbk., 2021)

2.10. Planning Area

Area that will be used as example for planning in this research are Jakarta, Surakarta, Lampung, Yogyakarta, and Sabang. The general data of planning areas in 2022 are obtained from the central statistic bureau. Table 9 shows the general information regarding these areas.

Table 9. Planning Area General Information in 2022.

City	Population	Area (km^2)	Population Growth Rate
Jakarta	10.534.339	653,83	0,57%
Surakarta	522.728	46,72	0,07%
Lampung	603.532	197,22	2,16%
Yogyakarta	3.712.896	3.133,15	1,1%
Sabang	42.066	153	2,82%

Source: (Badan Pusat Statistika, 2023e, 2023d, 2023c, 2023a, 2023b)

3. Research Methodology

The outline of this research can be divided into three parts: a Top-down approach, a modified model, and a forward calculation. The top-down approach is a method that collects several aspects, such as existing historical data, benchmarks from other countries, and results from network planning to obtain a price window that will be used as a guideline for new license fee prices that will not disrupt the telecommunication industry. The modified model is the model or formula made to change the component(s) of the ISR license fee, which is Ib and Ip, with several consideration aspects such as technological growth, industry stability, and common sense. The forward calculation aims to calculate the new ISR license fee using the modified model and sensitivity analysis to obtain a new license fee within the price window from the top-down approach. Figure 3 shows the research methodology.

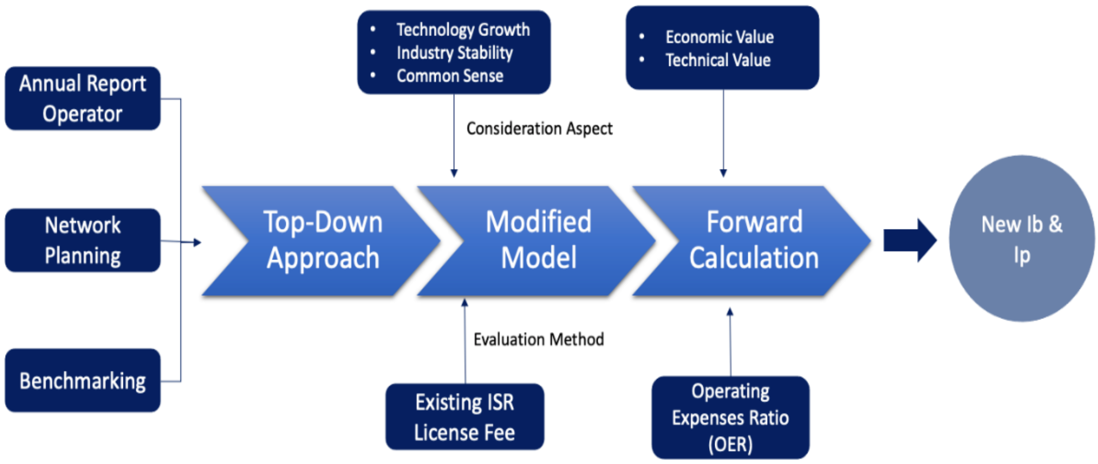


Figure 3. Research Methodology.

4. Results and Discussion

This research focused on modifying the ISR license fee components to recommend a new price. To make the recommended license fee as accurate as possible with field conditions, network planning is needed to know the estimated number of base stations needed for 5G operations in Indonesia. The planning area used in this research represents each zone applied in the zoning scheme ISR license fee.

4.1. Network Planning Results

From the coverage planning side, path loss calculation by using the excellent specification, as mentioned in Table 5, resulted in a 102.294 dBm uplink path loss and 111.294 dBm downlink path loss. These results can be used to calculate the distance between the base station and the user terminal using the UMi path loss model formula. The calculation result of the distance between the base station and user terminal (d3D) is 795.2 m for uplink and 5798.21 m for downlink, resulting in a cell radius of 5,42 km for uplink and 233,74 km for downlink. Table 10 shows the number of sites needed based on the coverage planning.

Table 10. Coverage Planning Results.

City	**Number of Site(s)**	
	Uplink	***Downlink***
DKI Jakarta	121	3
Surakarta	9	1
Lampung	37	1
Yogyakarta	578	14
Sabang	29	1

From the capacity planning side, the 5G initial users must be forecasted first to know the estimated traffic demand. The initial users are obtained using the bass diffusion model, which uses the population data as its base. Table 11 shows the initial 5G users up to 2026 and the estimated traffic demand.Table 11. Forecasted Traffic Demand Results.

City	Initial Customer	Traffic Demand (Gbps)
Jakarta	2.087.379	2,627
Surakarta	101.535	1,789
Lampung	127.334	0,531
Yogyakarta	751.194	3,134
Sabang	9.017	0,0

The site capacity calculation can be made by using the 5G throughput formula. The site throughput is then divided by the forecasted traffic demand, thus resulting in the base station needed per city to accommodate 5G usage. The throughput calculation resulted in 2259.95 Mbps or 2.25 Gbps per base station. Table 12 shows the number of sites needed based on the capacity planning.

Table 12. Capacity Planning Results.

City	Number of Site(s)
DKI Jakarta	2
Surakarta	1
Lampung	1
Yogyakarta	2
Sabang	1

The site needed based on the coverage and capacity planning has a big difference with the sites needed based on the coverage planning is higher. For this research, the number of sites needed taken from the coverage planning results. Because, if the lower number of sites chosen, in this case is from capacity planning, then the sites will not be able to cover the entire planning area. On the other hand, if the number of chosen sites is the higher number of sites, then the coverage and capacity requirement can be fulfilled.

4.2. Modified Model

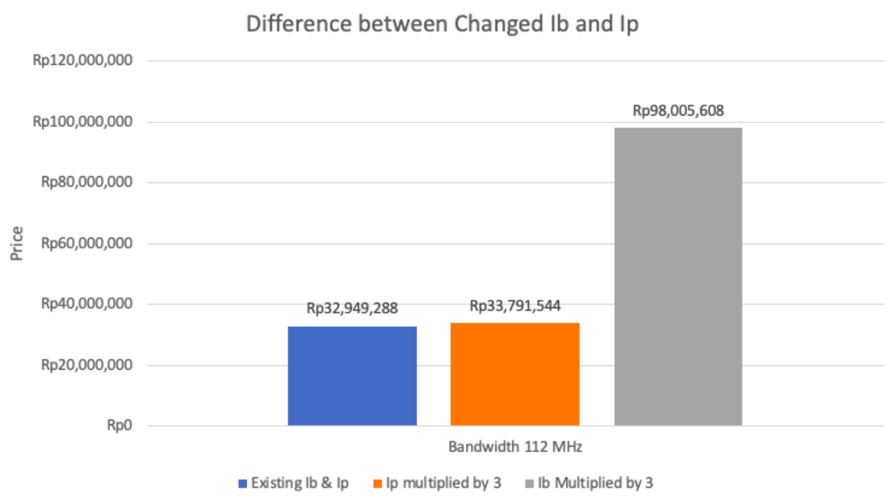
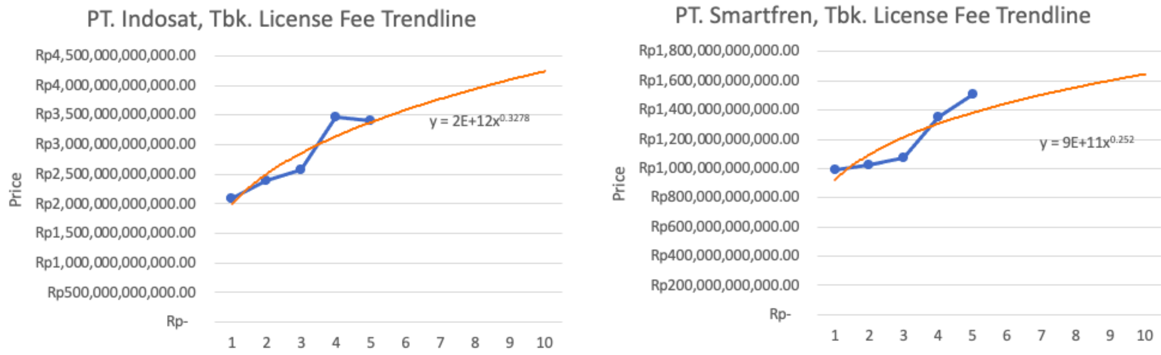


Figure 4. Difference between Changed Ib and Ip.

For the bandwidth index (Ib) and power index (Ip) changes in the ISR license fee formula, it is considered and recommended by the writer that the Ip, which represents the power value of the technology, in this case on Microwave Link, can be made 0. The reason for this decision is that there is only a minimal change when ip changed compared to when the Ib, which represents the bandwidth value of the technology, in this case on the Microwave Link, is changed and based on the benchmark country, the license fee is now leaning more towards the bandwidth usage rather than the coverage. Figure 4 shows the difference between Ib and Ip if their base index is multiplied by three.

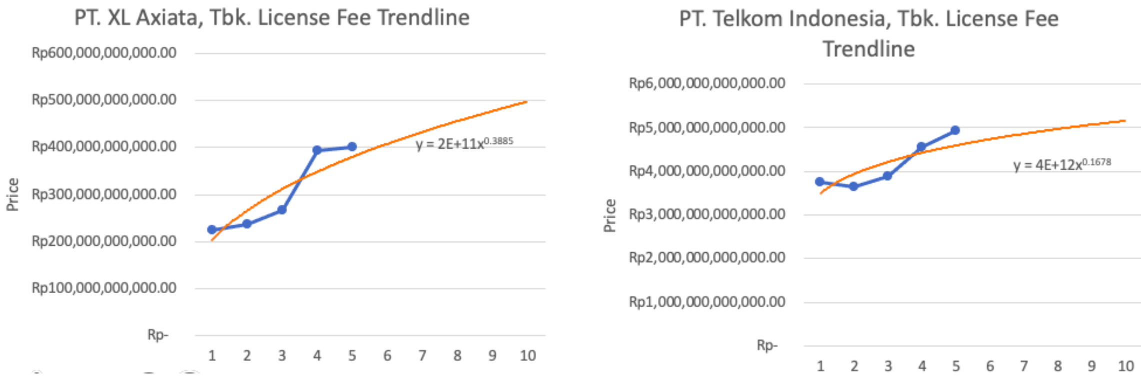
4.3. License Fee Price Window

The price window for license fees is obtained from the top-down approach. Data used for the top-down approach is the license fee paid by PT. Indosat, Tbk., PT. Telkom Indonesia, Tbk., PT. XL Axiata, Tbk, and PT. Smartfren, Tbk as shown table 8. These data are obtained from each company's Annual report and financial statements. The top-down approach takes historical data and forecasts it several years ahead to get the upper and lower bounds of the price to ensure that the recommended price will maintain the industry, in this case, the company's survivability. Using the data in Table 8, the trendline of the data can be seen in Figure 5, and Figure 6 shows each operator trendline for several years ahead.



(a) (b)

Figure 5. (a) PT. Indosat, Tbk. License Fee Trendline, (b) PT. Smartfren, Tbk. License Fee Trendline.



(a) (b)

Figure 6. (a) PT. XL Axiata, Tbk. License Fee Trendline, (b) PT. Telkom Indonesia, Tbk. License Fee Trendline.

As the graphs above show, all the ISR license fee datasets are increasing at a specific rate. Thus, the trendline used in all the forecasts is the power trendline. A power trendline is used when the dataset is increased at a specific rate. From the trendline, the ISR license fee that needs to be paid by operators until 2026 can be forecasted. Figure 7 shows the forecasted ISR license fee until 2026.

To get the upper bound and lower bound data, the ideal license fee increase along with inflation is needed. Therefore, the ideal data for ISR license fees from 2017 to 2026 can be calculated based on the existing data, the forecasted data, and the inflation data. Figure 8 shows the ideal or adjustment data from 2017 to 2026

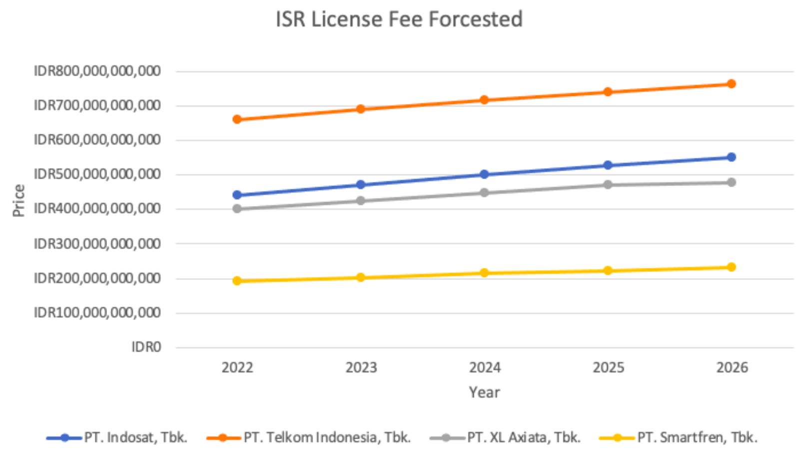


Figure 7. Forecasted ISR License Fee.

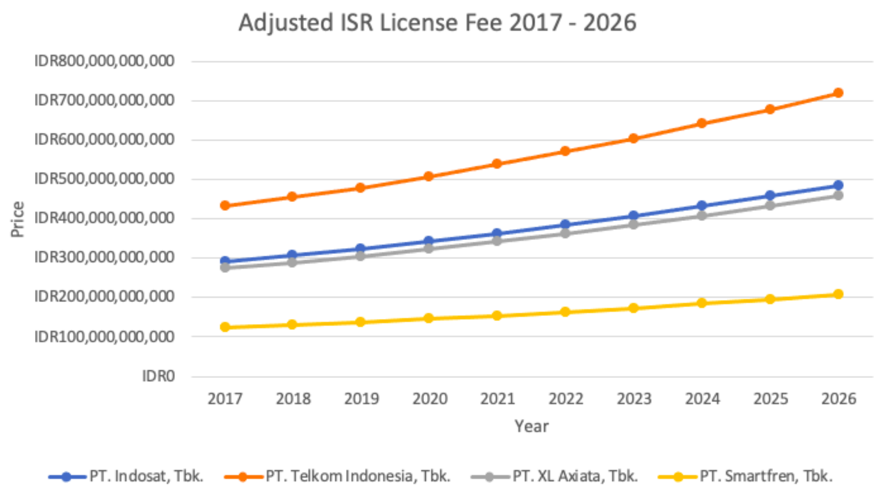


Figure 8. ISR Fee Data Adjustment.

The upper bound and lower bound can be obtained from the ideal or adjusted data in Figure 8 and forecasted data in Figure 7. The upper bound data is taken from the adjusted data, and the lower bound data is taken from the forecasted data. This price window is arranged to ensure that the new licensing fee pricing is not disturbing the industry and can still encourage operators to develop 5G tech further in Indonesia. Table 13 shows the upper bound and lower bound for each operator.

Table 13. Upper bound and Lower bound for each operator.

Operators	Lower Bound	Upper Bound
PT. Indosat, Tbk.	Rp 485,276,271,383	Rp 552,115,571,244
PT. Telkom Indonesia, Tbk.	Rp 718,772,049,418	Rp 763,941,303,426
PT. XL Axiata, Tbk.	Rp458,061,752,551	Rp 489,249,055,210
PT. Smartfren, Tbk.	Rp 206,658,776,324	Rp 231,846,209,541

4.4. Ib Modified Model

To get the new Ib value, a new formula is proposed to consider the existing Ib, band range and bandwidth that will be used. These considerations are taken to consider the economic value and technical value of the frequency and the bandwidth itself. Therefore, the new proposed formula for new Ib is as follows.

$$I_{b-new} = I_{b-existing} \times M_{factor} \quad \text{12)}$$

$$M_{factor} = f_s \times B_r \quad \text{13)}$$

$$B_r = \frac{B}{B_0} \quad \text{14)}$$

M_{factor} containing f_s and B_r where f_s is the sub service frequency on the Microwave Link service, and B_r is the relative bandwidth to the bandwidth used. B_r is composed of B bandwidth that used on the used bandwidth and inversely proportional with the smallest bandwidth, on this case is 14 MHz.

Components that will be used to determine the new Ib will have a different impact. The f_s component will push a higher frequency, so that the higher the frequency, the value of f_s will be smaller and making it more economic, because higher frequency means that the frequency is more likely to be weaker to noise and interference. The B_r component considers the bandwidth value from an industrial point of view. Higher bandwidth meaning higher B_r meaning higher price, because higher bandwidth gives bigger capacity and higher data rate. The existing Ib is used as a "fence" so the new value is not too far from the original value and make the new price too high.

4.5. New License Fee Price

A sensitivity analysis is used in the Ib to achieve the desirable license fee. The sensitivity analysis is done by changing the M-factor on the modified model to get the desirable Ib. Figure 9 shows the sensitivity analysis for Ib based on the top-down approach.

From Figure 9, when the Ib reaches the value of 0.266, PT. Smartfren, Tbk. It is starting to reach its upper bound limit; meanwhile, the other companies still need to reach their lower bounds. When the Ib value is 0.266, and the Ip value is 0, the base price of the license fee per radio station becomes Rp. 144,208,176 and raised around 337,67% from Rp. 32,949,287, which is the existing price. This pricing based on the smallest upper bound from four operators is too expensive even though it is still within the price boundary.

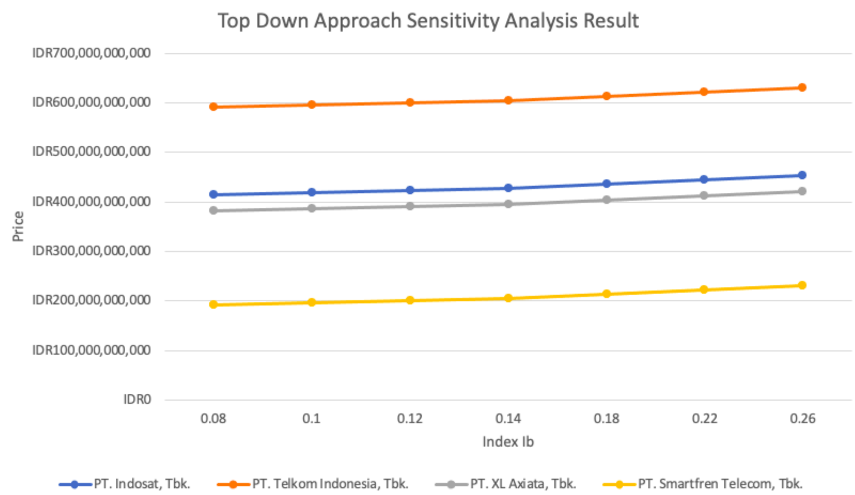


Figure 9. Top-Down Approach Sensitivity Analysis Results.

Therefore, the proposed license fee is **Rp. 81,320,400** which is taken from the lowest price boundary that belongs to PT. Smartfren Telecom, Tbk. The reason is that even though the license fee pricing is rising by 146%, the operator still can survive based on the OER that still in the ideal range after applying the proposed license fee. Figure 10 shows the new license fee for all bandwidth in 28 GHz frequency.

The M_{factor} that used to obtain Ib value of 0.15 is 2.5. From this, then the Fs can be calculated. Table 15 is the components of the newly proposed Ib. While Figure 11 shows the amount of license fee that need to be paid by operators based on the proposed license fee.

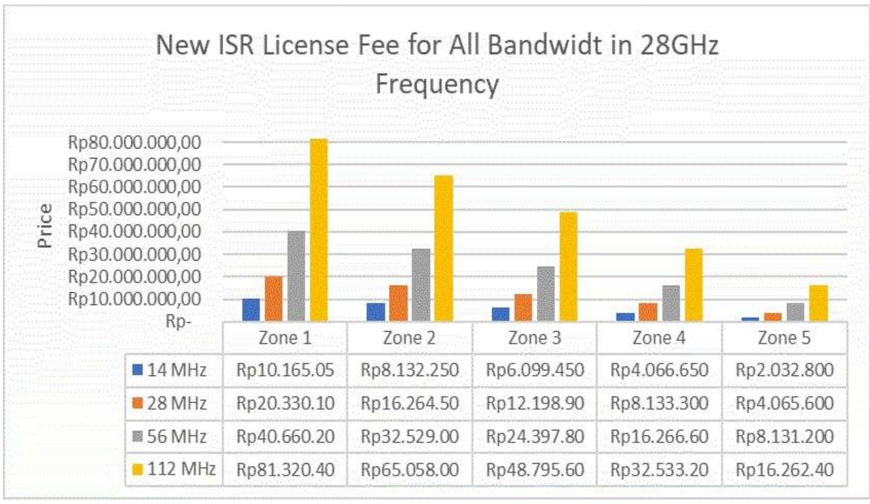


Figure 10. New ISR License Fee for all bandwidth in 28 GHz frequency.

Table 14. Proposed Ib Components.

Frequency Range	Existing Ib Value	Bandwidth (kHz)	M-Factor		Proposed Ib
			Fs	Br	
27,500 – 29,500	0.06	14,000	1,25	2	0.15
		28,000	0,625	4	
		56,000	0,3125	8	
		112,000	0,15625	16	

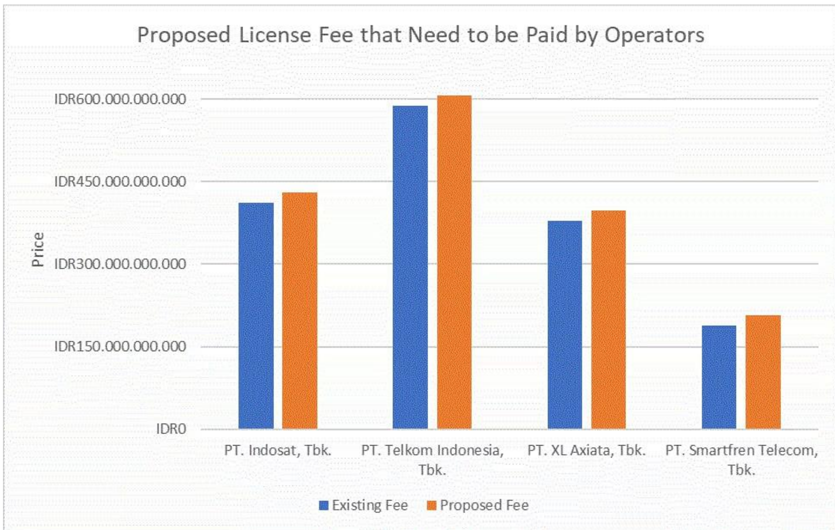


Figure 11. License Fee need to be Paid by Operators based on Proposed Price.

If the new proposed license fee is compared to the benchmarked countries, the new proposed license fee is still under Australia's license fee and far below India's license fee. The reason is that Indonesia's GDP is around 1.1 trillion USD, compared to Australia's 1.5 trillion USD and 3.1 trillion USD. Indonesia cannot raise its license fee compared to Australia's license fee, let alone to India's license fee. It is most likely because of each country's GDP, population, and percentage of working labor. However, it is still raised by 146.8% from the existing price without disrupting the industry, which the resulting OER proves with the proposed license fee.

Table 12. OER Differences

Components	PT. Indosat, Tbk.	PT. Telkom Indonesia, Tbk.	PT. XL Axiata, Tbk.	PT. Smartfren, Tbk.
OER	34,50%	47,12%	47,87%	60,79%
OER + Existing 5G Backhaul License Fee	34,54%	47,13%	47,92%	60,92%
OER + Proposed 5G Backhaul License Fee	34,60%	47,15%	47,99%	61,09%

The newly proposed Ib and license fee are then tested to see the OER difference between the existing and proposed license fees, Table 12. shows the OER difference. The OER for the highest company as a benchmark is still within the ideal OER range of 61.09%, and the other three operators are within 40% of OER. The recommended license fee can make the frequency of usage more efficient, not disrupt the technology deployment, and contribute more to the state income.

5. Conclusion and Recommendations

5.1. Conclusion

Based on the planning results, the coverage of a gNodeB in this research has a cell coverage of up to 5,42 km for uplink and 233,74 km for downlink, and the capacity of gNodeB can generate throughput up to 2259.95 Mbps or 2.25 Gbps per base station. Because of the difference between the results of sites needed to be based on coverage and capacity planning, the number of sites required to deploy 5G is taken from the coverage planning because it is higher than the capacity planning results and thus can meet both requirements from both coverage and capacity sides.

For the five areas used in this research, the number of base stations needed is around 774 to deploy 5G that can cover the entire area. Based on the number of sites needed, it can be estimated how much cellular operators must pay for the frequency license fee to use the 5G wireless backhaul frequency legally. From the upper and lower bound prices obtained via the top-down approach, it can be concluded that the recommended price for the new ISR license fee is Rp. 81,320,400 per base station. Even though the price is raised by more than 100% from the existing price, operators can still pay the fee and still survive without disrupting the industry balance because the proposed price is on the lower bound of the price window, the OER of the operators also still in the ideal range which is around 60% and lower.

Compared to the benchmarked countries, the new pricing is still lower by 75% compared to the closest license fee pricing, which is from Australia. The reason is that Indonesia's GDP is still behind the other countries, meaning that the buying power of its people is also below other countries. Therefore, some countries can only reach the recommended license fee price.

5.2. Recommendation

For further research, it is recommended that the zoning of the ISR license fee is reviewed to reflect the current economic power of each city and province.

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