

INDONESIA DIGITAL INFRASTRUCTURE BEST PRACTISE, GIGA CITY INITIATIVE TOWARDS THE DIGITAL VISION 2045

White Paper 2023



Table of Contents

1. Foreword: Minister of Communication and Information (KOMINFO)	02
2. Foreword: The Indonesian Telematics Society (MASTEL)	03
3. Foreword: Telecommunications Network Providers Association (APJATEL)	04
4. Preface	05
5. Digital Giga City, Vision and Initiatives	06
5.1. Investment in ICT Infrastructure Drives Digital Economic Growth	07
5.2. Definition of Indonesia Digital Vision 2030/2045	08
6. Indonesia Digital Infrastructure, Conditions and Challenge	10
6.1. Current Condition of Internet in Indonesia	11
6.2. Indonesia Fiber Development as Digital Infrastructure Backbone	12
6.3. Challenges in Indonesia Digital Giga City Infrastructure	16
6.4. Digitalization Prospective in Surakarta City	19
7. Indonesia Giga City, Implementation and Initiative	21
7.1. Mobile and Fixed Broadband Networks in Surakarta City	22
7.2. Surakarta City Digital Vision and Plan	24
7.3. Fiber Optic Policy Optimization	26
7.4. STP (Solo Techno Park), An Example of Giga Campus	27
7.5. Giga City Fiber Optic Development	28
8. Recommendation	30
9. Glossary	33



Wayan Toni Supriyanto, S.T., M.M **Minister of Communication and Information** **(KOMINFO)**

In 2022, Indonesia's GDP (Gross Domestic Product) reached US\$1.32 trillion with a GDP growth rate of 5.31%, the highest since 2013. Meanwhile, Indonesia's GDP per capita reached US\$4,783.9.

Indonesia digital economy is predicted to grow rapidly in the future, reaching a value of US\$315-360 billion by 2030. Demand for the digital economy is so strong, and Indonesia is now facing a golden age.

With a population of more than 277 million, Indonesia is the most populous country in ASEAN. Around 55% of the population lives in Java, while GDP of top 10 metropolitan cities contributes for 53% of the country GDP.

Amidst such great potency, the urbanization level is imbalanced, and the need for infrastructure development varies widely. Indonesia is the largest archipelagic country in the world with more than 16,700 islands. Due to its unique geographic characteristics, infrastructure development and implementation are more challenging compared to other countries.

As the largest democratic country in ASEAN, the Indonesian government needs to align the interests and needs between central and regional governments, state-owned and private companies, encourage infrastructure development, and accelerate digital transformation. Currently, a number of local governments are already aware of the importance of fiber optic infrastructure networks to support government digital transformation to become a smart city.

The Smart City of Observatory by IMD (International Institute for Management

Development) World Competitiveness Center released the Smart City Index (SCI) 2023 included three cities in Indonesia, namely Jakarta, Medan and Makassar, among the 141 influential smart cities in the world. IMD World assesses that the presence of technology in these three cities can provide better public services such as transportation, sanitation, access to information, and access to health for their citizens. However, smart cities in these three cities can still be developed because they are currently ranked 100 and above.¹

Apart from Jakarta, Medan, and Makassar, several cities in Indonesia are also aware of the importance of digital infrastructure to support better, faster, and more transparent services. Denpasar, Semarang, and Surakarta see the importance of digital infrastructure in creating a smart city.² They are competing to reach this goal by creating policies supporting the acceleration of digital transformation, one of the policies is sharing utilities.³

Surakarta City Government collaborates with the private sector to boost the presence of fiber optic network to liven up the Solo Techno Park, a Giga City pilot area in Surakarta. It is hoped that in the future Solo Techno Park will make a real contribution to the progress of Surakarta City.

Many cities in Indonesia are motivated to participate in the innovation and development of digital infrastructure which will stimulate digital and intelligent applications in all industries, enrich and bring into reality the implementation path of the Digital Indonesia Vision (VID) 2045, which has been formulated as a strategic policy direction and has become a preparation material of RPJMN 2025-2029 and RPJN 2025-2045.

¹ <https://www.cnbcindonesia.com/lifestyle/20230405132313-33-427567/keren-tiga-kota-di-indonesia-masuk-daftar-smart-city-dunia>

² <https://www.linknet.id/article/contoh-smart-city-di-indonesia>

³ <https://industri.kontan.co.id/news/pemkot-yogyakarta-bisa-jadi-contoh-ideal-gratiskan-sjut-dan-mewujudkan-smart-city>



Sarwoto Atmosutarno **The Indonesian Telematics Society (MASTEL)**

Indonesia digital economy is at a stage of great development. However, it is limited by digital infrastructure, mainly fiber infrastructure, computing infrastructure, and next-generation wireless network infrastructure.

Currently, the country and Indonesia's social and economic organizations have investment plans for digital transformation. These investments are aimed at ensuring Indonesia's dominant position in ASEAN (40% of the total value of ASEAN's digital economy currently comes from Indonesia⁴) in the medium and long term, especially in digital finance and platform economy. Under this background, not only on the consumer side, Indonesia's traditional industries, including our large agriculture, marine economy, and Indonesia's manufacturing industry, are also facing a great opportunity for digital transformation. The content of this white paper is very relevant to the theme of digitalization, stimulated by supply and demand.

Some cities such as Surakarta, Depok, Bogor are trying to find their own digitization development path based on the actual situation. Surakarta has made a pioneering attempt at Solo Technopark as Giga City showcase. This is not just a concept, nor is it just a government administrative program. We hope to provide the Indonesian people with a faster, more reliable, and future-oriented digital transformation foundation through a series of new supporting policies, such as Giga City.

We hope that more and more cities in Indonesia will have their own creative and practical ICT infrastructure development plans to achieve scientific, orderly, and efficient development.

⁴ <https://asean2023.id/en/news/aseans-digital-economy-to-reach-us2-trillion-by-2030>



Jerry Mangasas Swandy **Telecommunications Network Providers Association** **(APJATEL)**

Organizations in Indonesia are trying to accelerate digital transformation as the society now become more dependent on the internet. Alas, deploying fiber optics, which is the backbone of data services and other telecommunications infrastructure, is full of challenges.

One of the obstacles and becomes a problem experienced by fiber optic providers when developing a network is no standardisation related to permits and fees charged between institutions. Providers are also faced with network privatization, which makes it difficult for business to enter an area. In some regions and districts, deploying cost of fiber optic cables are quite expensive, including when the fiber optic network has to cross the railway network. There are policy differences between each office of Indonesian Railway Operation Area (DAOP) and the Director General of Railways. In addition, fiber optic providers also have to take long permit procedures when the cable passthrough the protected forest areas.

On the contrary, the demand for fast internet also continues to increase. The Federal Communications Commission recommends the internet speeds must reach 40 to 100 Mbps, whereas, Indonesia is still around 23 Mbps for mobile and 27 Mbps for fixed broadband⁵.

APJATEL commit to continue giving maximum support in providing network to various sectors. As more communities, societies, and various sectors enter the digital field, APJATEL will be more challenged to support it. As more people need connection, APJATEL must compete to provide networks so the business can grow even more and use the telecommunications networks for good things.

Since it was first used in 2005 until now, fiber optic penetration has only reached 30% in Indonesia. Meaning, there is still 70% unreached areas because of some reasons mentioned above. Hence to overcome this requires collaboration from all parties, amongst the private sector, government, and society.

With good collaboration, APJATEL hopes fiber optic penetration can grow from 30% currently to 80% by 2045, that more giga connection reach urban areas, more smart cities in Indonesia, with a better service experience as a result of digitization⁶.

The development of Giga City in Surakarta could be an example of how fiber optic infrastructure contributes so many benefits for digital innovation, from the education sector to the economy. Surakarta, which is supported by gigabyte infrastructure, can be a reference for other cities in Indonesia.

⁵ <https://www.speedtest.net/global-index/indonesia>

⁶ <https://apjatel.id/blog/eksklusif-ketum-apjatel-jerry-mangasas-swandy-baru-30-persen-wilayah-indonesia-terlayani-jaringan-fiber-optik/>

Indonesia is highly motivated to encourage the fixed internet penetration. Refer to APJII (Indonesian Internet Service Providers Association) report, current fixed broadband penetration in Indonesia is below 30%. Inline with the massive penetration of fixed internet access networks, the government targets that by 2030 the number of Indonesian internet users will reach more than 86% of the population, where the number of cities/regencies cover with fiber optic reaches more than 80% of subdistricts throughout Indonesia.⁷

However, this target will be difficult to achieve without strategic moves. Amidst the challenges of deploying fiber optic infrastructure and regulatory disharmony, the Indonesian government must set more aggressive targets, not only determine fundamental target indicators but also the challenged targets to guide and accelerate overall target achievement. Besides, the fiber optic penetration measurement must include fiber coverage level to the homes, to the wireless sites, to the buildings, up to the rooms.⁸

By thoroughly calculating the deployment of fiber optic infrastructure and the readiness of gigabit connectivity, the digital transformation process will be carried out faster and create a Giga City, a city with digital infrastructure up to gigabits. High-quality giga connectivity will enhance the broadband experience for home and enterprise users.⁹ Encourage reduction of single-bit bandwidth costs and promote large packets. Giga connectivity will boost the giga

application innovation which will encourage the entire industry to grow along with the manifestation of those new services.

In Indonesia, giga infrastructure has been developed in Surakarta through fiber optic network. Some use cases are prepared and tested to ensure the best advantages which can be implemented.

From fiber optic policy perspective, the government should provide convenience and incentives to telecommunications network operators to optimize right-of-way approval procedures, by reducing Service Level Agreements (SLA), one stop agreements, and reducing rental costs. Facilitate the fiber optic deployment also needs to be applied through system of sharing infrastructure related to joint planning and development, exploring policies, and reusing public infrastructure.

Through these moves, it is hoped that fiber-to-the-home (FTTH) penetration can grow without raising prices, stimulate and encourage home and enterprise users to take advantage of fiber broadband and accelerate Fiber to The Room (FTTR) packages.

The availability of optimum fiber optic infrastructure will increase competitiveness of society and digital innovation in various industries, as well as encourage the country to manifest the Digital Indonesia Vision (VID) 2045 faster, considerably, efficiently, and with higher quality.

⁷ White Paper Indonesia Emas 2045.

⁸ <http://id.fttxsolution.com/info/what-is-fttr-fiber-to-the-room-58051665.html>

⁹ https://digital-strategy-ec-europa-eu.translate.goog/en/library/connectivity-european-gigabit-society-brochure?_x_tr_sl=en&_x_tr_tl=id&_x_tr_hl=id&_x_tr_pto=tc



5 | Digital Giga City, Vision and Initiatives

5. Digital Giga City, Vision and Initiatives

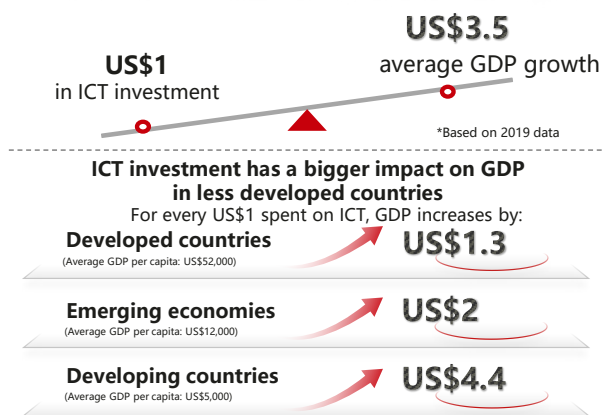
5.1. Investment in ICT Infrastructure Drives Digital Economic Growth

Indonesia digital economy has an immense potency to grow, reaching US\$360 billion by 2030. Besides, Indonesia has also taken the lead in ASEAN digital growth by contributing 40% of total digital economic transaction value, where 98% of merchants have adopted digital payment methods, and 6th rank in fostering start-ups in the country.

In global environment, analysts conclude that many countries have achieved higher GDP growth by prioritizing a digital economy enabled by ICT investments. In developing countries, the benefits of ICT investment are more significant, reaching 2-4 times.

Developing countries believe that building a robust digital infrastructure foundation, including strong 4G/5G and fiber connectivity, supported by a national fiber network and synergized with a national cloud platform, is fundamental to achieve the growth. A strong digital infrastructure foundation can effectively support short-medium term digital economic growth needs and amplify national digital competitiveness in the long term.

More ICT investment, faster GDP growth



Source: Roland Berger

Figure 1. ICT investment impact/Source: Roland Berger (2019).



Figure 2. The role of fiber optic, 4G/5G and cloud infrastructure in boosting Indonesia digital competitiveness/Source: Huawei.

5.2. Definition of Indonesia Digital Vision 2030/2045

The Indonesia Digital Vision (VID, Visi Indonesia Digital) 2045 is a long-term planning concept in the digital sector to orchestrate stakeholder interests from sectoral and regional perspectives. Indonesia Digital Vision (VID) 2045 provides vision, mission, targets, and digital development strategies to reach Golden Indonesia 2045.¹⁰

In VID 2045, Indonesia aims to become a country with fifth-largest Gross Domestic Product (GDP) income in the world by 2045. One of the steps to be taken to accomplish vision and mission is optimizing the advantage of digital technology, considering in some developed countries the role of technology is very strong in encouraging economic growth.

As previously mentioned, VID 2045 has four pillars to be achieved by 2030, which are digital infrastructure, digital economy, digital government, and digital society. Each of these pillars has key performance indicators to be achieved.

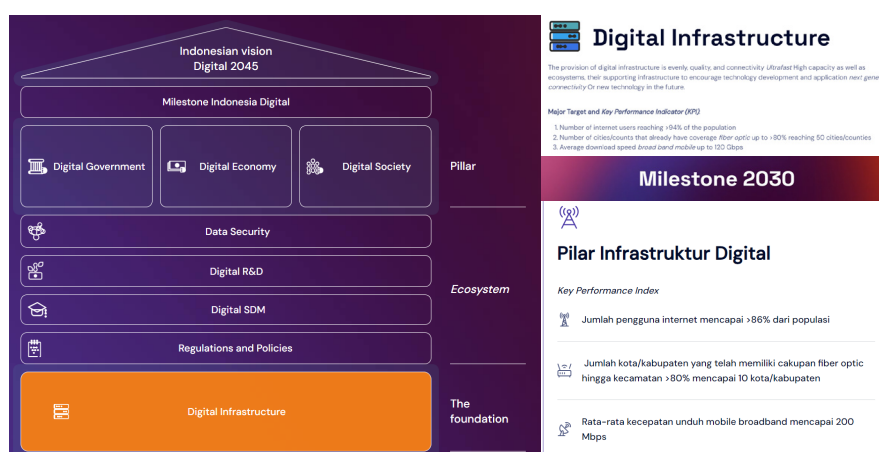


Figure 3. Indonesia Digital Vision 2045 framework/Source: Website Visi Indonesia Digital 2045.

In the digital infrastructure pillar, government targets that 86% of the population is internet reachable by 2030. This number is relatively high, considering that in 2023 Indonesia internet penetration is still 77% with around 213 million internet users according to data from Indonesian Internet Service Providers Association (APJII).¹¹

In terms of quality, government targets the average mobile internet speed reach 200 Mbps by 2030, eight times higher than mobile internet speed in the third quarter of 2023, which was 24.3 Mbps according to Speedtest report by Ookla, and 21.1 Mbps according to Opensignal report in October 2023.

This high quality internet is fulfilled through fiber optic network in more than 80% of subdistricts in 10 cities/districts. When digital infrastructure pillar is accomplished, the value of Indonesia digital economy is expected to reach US\$315-360 billion by 2030, which can be optimized to develop the country.

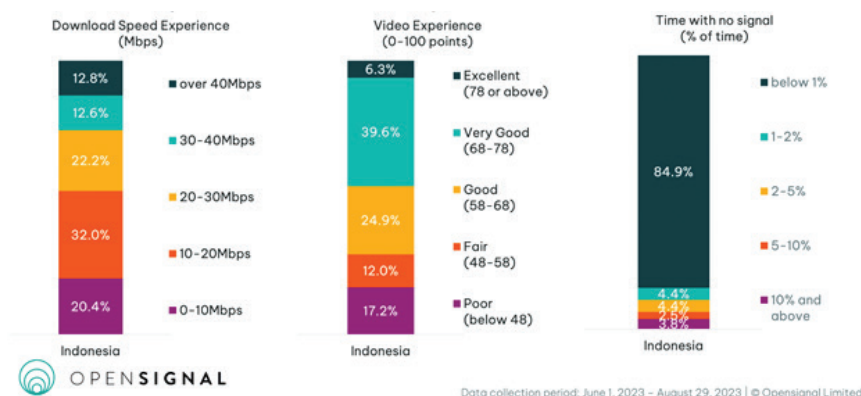


Figure 4. Average download speed of smartphone users in Indonesia, June-August 2023/Source: Opensignal.

¹⁰ <https://digital2045.id/>

¹¹ <https://digital2045.id/>

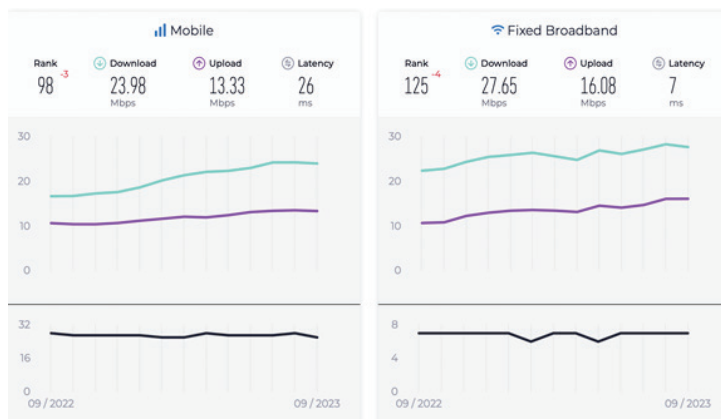


Figure 5. Internet speed in Indonesia at the third quarter of 2023/Source:Speedtest.

VID 2045 sets out eight strategies in implementing the vision. The said programs are providing connectivity which are equitable, high-quality, high-capacity, along with the infrastructure and technology ecosystem; mastery of future digital technology based on research and innovation to develop and strengthen sustainable economic, social and

governance; maintain data sovereignty and protect people privacy with policies, regulations and cooperation; strengthen the cybersecurity ecosystem to support safe digital transformation; create competitive and productive digital society by developing digital literacy and culture, as well as strengthening universal digital education and training; establish adaptive regulations and institutions in the national digital ecosystem; create conducive environment to promote investment in the digital sector; and boost collaboration amongst stakeholders in developing and utilizing digital technology equitably across all regions of Indonesia.¹²

As an association focus on deploying telecommunications infrastructure, Association of Telecommunications Network Providers (APJATEL) is committed to support the implementation of digital infrastructure in line with the pillars and programs targeted by the government. APJATEL believes that Indonesia must build national productivity competitiveness to reach those common goals. The key factor is optimizing national digital technology utilization.

The high level of digitalization in developed countries is a proof that utilizing digital technology is one way to uplift the national economy. VID 2045 which is initiated by Kominfo, is a long-term planning in the digital room concept to eradicate the interests of stakeholders who have sectoral perspectives and areas.

VID 2045 defines the vision, mission, targets, and digital development strategy to reach Golden Indonesia 2045. Digital infrastructure as the foundation of VID 2045 framework, is expected to establish more smart cities and meet the criteria of Smart City Index (SCI) like Jakarta, Medan, and Makassar, followed by Surakarta which are already on their path to be Giga City.



¹² <https://digital2045.id/>



6

Indonesia Digital Infrastructure, Conditions and Challenge

6. Indonesia Digital Infrastructure, Conditions and Challenge

6.1. Current Condition of Internet in Indonesia

Indonesia is currently ranked 16th in the world in terms of GDP and has the ambition to become the country with the fifth-largest economy in the world by 2045. However, citing from Ookla data, Indonesia internet quality is still ranked low globally and in ASEAN, especially in fixed and mobile broadband. This is contradictory to Indonesia economic status and goals in the future.

In 2022, Indonesia GDP reach US\$1,289 billion, far above Thailand (US\$534 billion), Malaysia (US\$434 billion), Singapore (US\$423 billion) and Vietnam US\$413 billion. Unfortunately, this is contrary when talking about internet speed.

According to Ookla report, the average internet speed in Indonesia in the same year was only 25.59 Mbps for fixed broadband and 21.35 Mbps

for mobile broadband. Indonesia dropped to rank 120th in the world for fixed broadband and 101st in the world.

For fixed broadband internet, Indonesia is behind Singapore (235 Mbps), Thailand (201 Mbps), Malaysia (98.91 Mbps), and Vietnam with the average internet speed of 91.24 Mbps. Singapore, Thailand, and Malaysia are countries whose governments are committed to support inclusiveness in fiber optic deployment.

Then, for mobile broadband, Indonesia ranks the lowest in Southeast Asia. It is far behind Brunei (78.09 Mbps), Singapore (76.48 Mbps), and Malaysia with the average internet speed of 47.72 Mbps.

Besides, Indonesia is also far behind in terms of

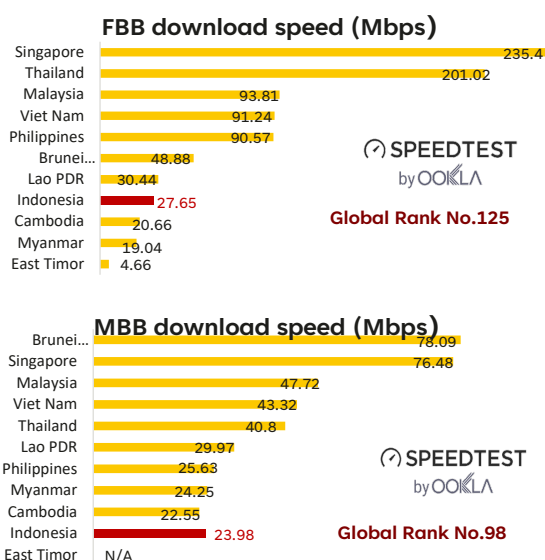


Figure 6. GDP 2022, FBB download speed, MBB download speed.

deploying the 5G network. The Opensignal report in June 2023 shows that globally Indonesia ranks at the bottom in 5G availability. Though it has been deployed since two years ago, 5G availability in Indonesia is inferior compared to neighboring countries, such as Malaysia and Vietnam.¹³

According to Opensignal, 5G availability in Indonesia is only 0.9%, after Vietnam 2% and Malaysia 20.5%. In Southeast Asia, Singapore is still the champion reaching 30%. In accordance with the low rate of 5G network availability in Indonesia, the average of 5G download speed is also below Thailand (99.7 Mbps), Philippines (136 Mbps) and Vietnam (217 Mbps).

¹³ <https://www.opensignal.com/2023/06/30/benchmarking-the-global-5g-experience-june-2023>

5G Availability– Global

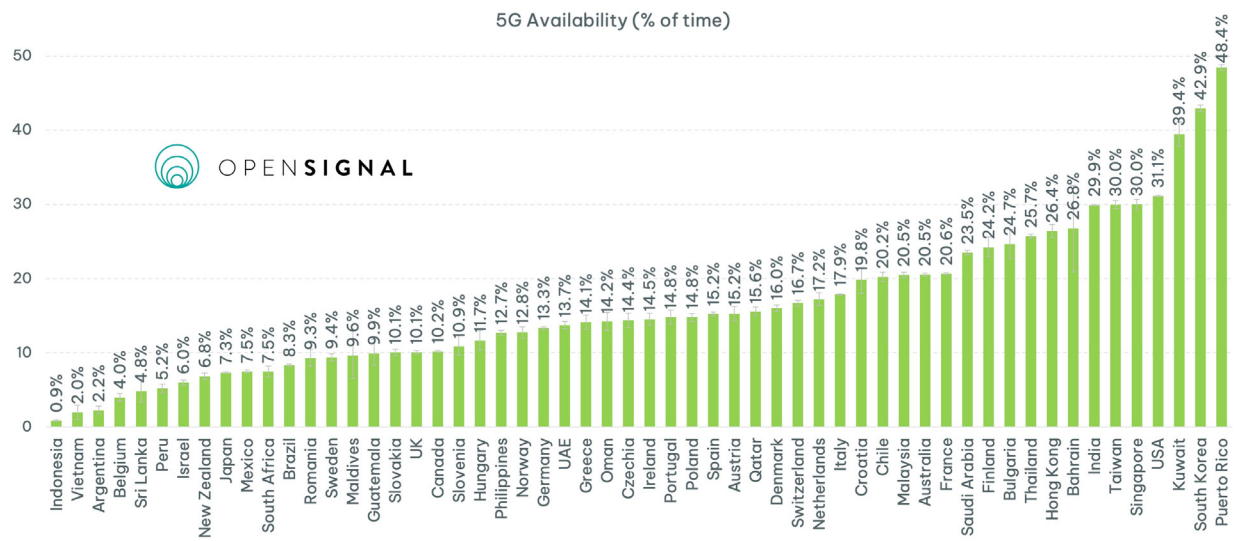


Figure 7. Global 5G Availability on March-May 2023/Source: Opensignal.

Many factors contribute to the 5G speed, such as spectrum allocation, base station coverage density, and base station backhaul technology.

From the perspective of fiber optic deployment in Indonesia, the presence of fiber optic network in every 5G base station can also increase the internet speed. Omdia developed a Fiber Development Index (FDI) measuring fiber coverage to wireless base stations, which is called fiber-to-the-cell-site (FTTS). Looking from FDI perspective, Indonesia is left behind than several Southeast Asian and global countries.

6.2. Indonesia Fiber Development as Digital Infrastructure Backbone

6.2.1. Fiber Development Index (FDI) Measurement

The Fiber Development Index (FDI) by Omdia tracks and measures fiber development in countries/regions globally. Indonesia is ranked 51st out of 93 countries in FDI 2023. Compared to leading countries, the current challenge for Indonesia is to accelerate fiber optic coverage and encourage further penetration fiber optics deployment to more

4G/5G wireless stations.

Omdia ranks Singapore with FDI value reach 95%, the highest score in Southeast Asia and in the world, as the result of Singapore government role which highly committed to establish Giga City and connect all over Singapore with fiber optic network.

Fiber Development Index Ranking split by cluster

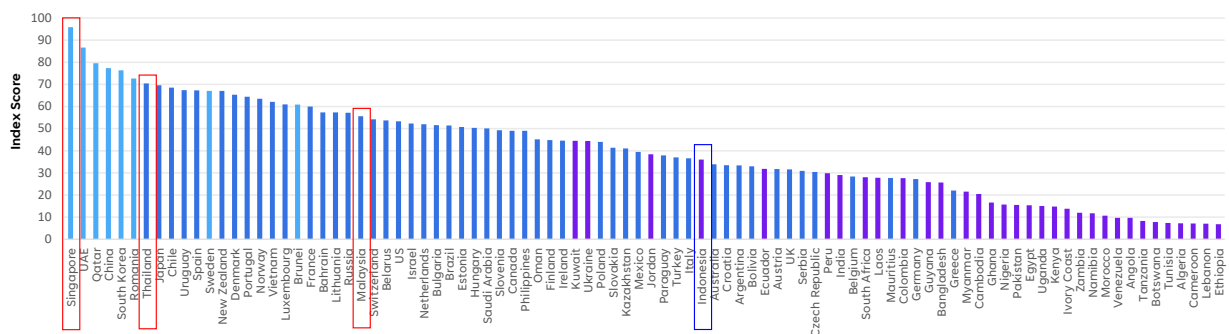


Figure 8. Fiber Development Index by cluster/Source: Omdia (2023).

© 2023 Omdia

Meanwhile, Thailand is behind Singapore with FDI of 70%, and Malaysia is following after Thailand with FDI of 55%. Meanwhile, Indonesia is in 51st place with a score of 37. In Southeast Asia, Indonesia is only ahead of Myanmar, a country with a relatively low commitment to deploy digital infrastructure compared to Thailand.

In measuring FDI, Omdia refers to a number of metrics that cover broader fiber investments, including fiber-to-the-premises (FTTP) coverage, investment in advanced technology Wavelength Division Multiplexing (WDM), fiber-to-the-home (FTTH) penetration, Fiber penetration to

Building (FTTB), and fiber penetration to cellular sites.

Furthermore, to measure the improvement in overall quality of broadband experience as a result of these investments, Omdia analyzes using data from Ookla the average download speed, upload speed, latency, and jitter.

Overall, Omdia divides into nine metrics with three dimensions, namely fiber coverage dimensions (FTTP coverage and WDM density), penetration dimensions (FTTP, FTTH, and Mobile station), and broadband experience (average download, upload, latency, and jitter).

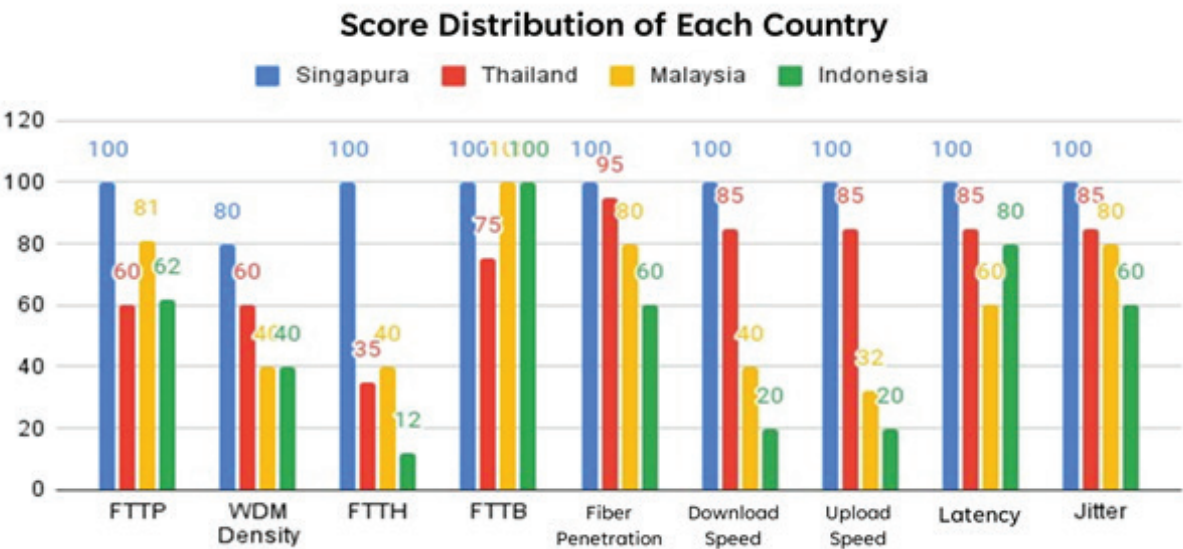


Figure 9. Score distribution of each country/Source: Omdia (2023).

From all these metrics, it is shown that compared to Singapore, Malaysia, and Thailand, Indonesia has the lowest score for all dimensions.

From coverage perspective, Indonesia FTTP coverage score is 62% slightly lower than Thailand, nonetheless far behind Malaysia. The WDM density score is even lower at 40%, which is far different from the mentioned three countries.

Then, from penetration perspective, Indonesia FTTH penetration score is

only 12%, inversely FTTB penetration is 100, and the score for fiber optic penetration to BTS is 60%.

In line with low penetration of FTTH and fiber optic to BTS, Indonesia average internet speed is 20%, lower than Singapore, Thailand, and Malaysia. The experience in latency and jitter are still good with scores of 80% and 60%, same as the mentioned three countries. Based on this report, it can be interpreted that there are a number of problems that must be resolved together.

6.2.2. Future Trends

The presence of fiber optic infrastructure to support rapid technological developments is urgently needed. Giga infrastructure based on fiber optic networks has advantages to keep pace with technology development in a city.

As informed that in the era of information, technology, and networks continues to change every day. Over a hundred years ago, Alexander Graham Bell invented the optical telephone, taking the first step in the history of modern optical communications. Fifty years ago, Dr. Gao Kun proposed fiber optic as communication transmission media, which then brought optical communication into a new phase.

Forty years ago, the world's first fiber optic communications route between Washington and Atlanta was launched, leading to a new era of optical communications. Broadband access undergone rapid development in the era of narrow band PSTN (Public Switched Telephone Network)/ISDN (Integrated Services Digital Network), the wide band ADSL (Asymmetric Digital Subscriber Line)/VDSL (Very High Bit Rate Digital Subscriber Loop)/ultra-broadband, and GPON (Gigabit-capable Passive Optical Networks)/EPON (Ethernet Passive Optical Network) surpassing the 100 Mbit/s era.

Optical transport undergone a high-speed evolution from multi-mode systems, PDH (Plesiochronous Digital Hierarchy), SDH (Synchronous Digital Hierarchy), and WDM (Wavelength Division Multiplexing)/OTN (Optical Transport Network). The capacity of a single fiber has changed from tens of Mbit/s to tens of Tbit/s. Starting from fulfilling basic connection requirements to providing a 4K HD video experience, fixed networks have improved the life quality of society significantly.

In this digital era, network technology keep surging forward, then emerging the F5G (Fifth Generation Fixed Network). In 2020, ETSI (European Telecommunications Standards Institute) officially released F5G, which carried out the industry vision of "Fiber to Everywhere" and defined three general technical features: eFBB (Enhanced Fixed Broadband), FFC (Full Fiber Connection), and GRE (Guaranteed Reliable Experience). Global fixed network broadband is entering the fast track rapid development.

In the next decade, the number of VR (Virtual Reality)/AR (Augmented Reality)/MR (Mixed Reality)/XR (Extended Reality) users will exceed 1 billion. The virtual and physical integration meta-universe will initially be realized. Gigabit access will be widely used and 10GE access will be commercially applied on a large scale.

Enterprise cloudification and digital transformation will continue to occur and deepen. The intelligent era of the Internet of Everything (IoE) is speeding up. The networks remain facing extraordinary opportunities.

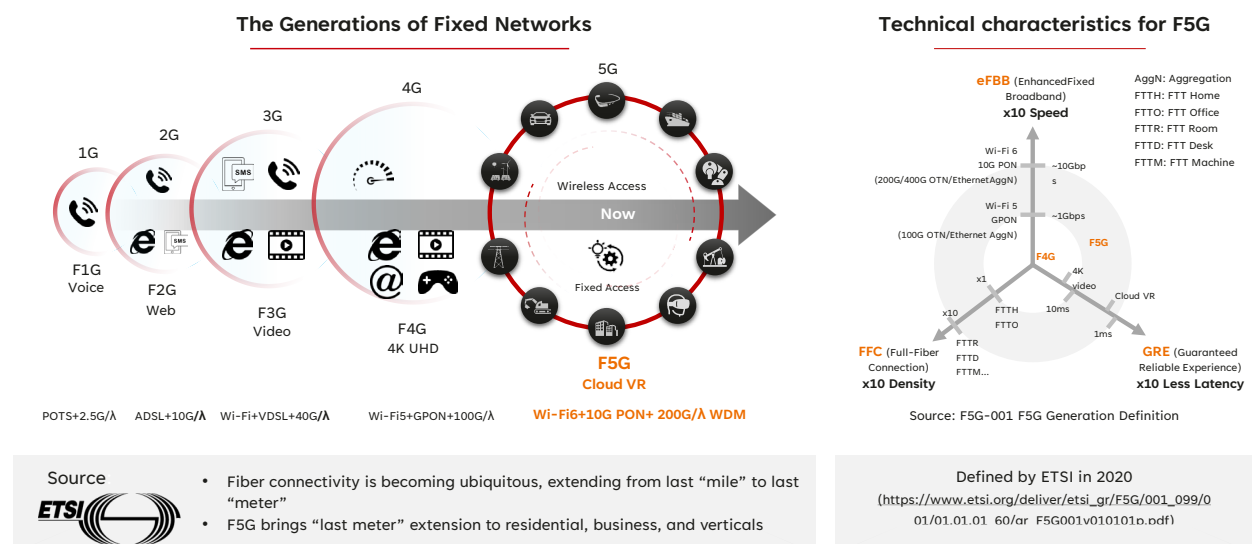


Figure 10. Technology development 1G-4G/Source: ETSI (2020).

With the rapid demand to develop services such as smart homes, industrial digitalization, green network construction, and synaesthesia integration, lead operators to start exploring the second growth curve, such as cloud, data center, and DICT (Department of Information and Communications Technology).

Consequently, the network needs to be improved and developed continuously in order to provide different type of service capabilities. The era of F5G A (F5G Advanced) will come by 2025. F5G A is the next generation standard which is proposed by ETSI based on F5G, led by ETSI and co-defined by the industry, and oriented towards the evolution of fixed networks from 2025 to 2030.

This is further improvement of F5G scenario and technology. In September 2022, ETSI released the white paper "Fixed 5th Generation Advanced and Beyond", which proposed the development guidance and goals to enter the F5G Advanced. In 2023, ETSI started the formulation of the F5G Advanced standard. This marks the entry of inter-generations standards into the era of F5G A.

Compared to F5G, F5G A further improving its capacities in these three dimensions: enhanced Fixed Broadband (eFBB), Full Fibre Connection (FFC), and Guaranteed Reliable Experience (GRE).

Furthermore, some new feature dimensions have been added to Green Agile Optical (GAO), Real-time Resilient Link (RRL), and Optical Sensing and Visualization (OSV) networks. This is the refined and developed version of F5G. The service feature of F5G is gigabit while the F5G Advance is 10 GE (Gbps Everywhere), a significant improvement in the eFBB dimensions.

With higher speeds compared to previous technology, F5G A can support metaverse applications and immersive services. In addition, a faster network is able to support solutions for industry, applications, and tactical internet. F5G A is also more visualized and sensitive, with more efficient deployment cost. The technology will then develop into F6G (Sixth Generation Fixed Network) by 2030, offering a better connectivity quality compared to previous technology.

Considering the importance of fiber investment and its impact on global development, Omdia set up the Fiber Development Index (FDI) for fiber optic benchmark. Unlike other benchmark tools which only tracking one metric of development, such as household coverage or penetration, FDI aims to capture all elements of fiber network investment: overall fiber access coverage and the penetration rate of Fiber to The Home (FTTH), Fiber to The Building (FTTB), cellular fiber backhaul, and advanced WDM fiber core technology.

Furthermore, FDI also aims to measure the investment results in terms of overall broadband experience in the country, measured the median of download and upload speeds, as well as median latency and network jitter.

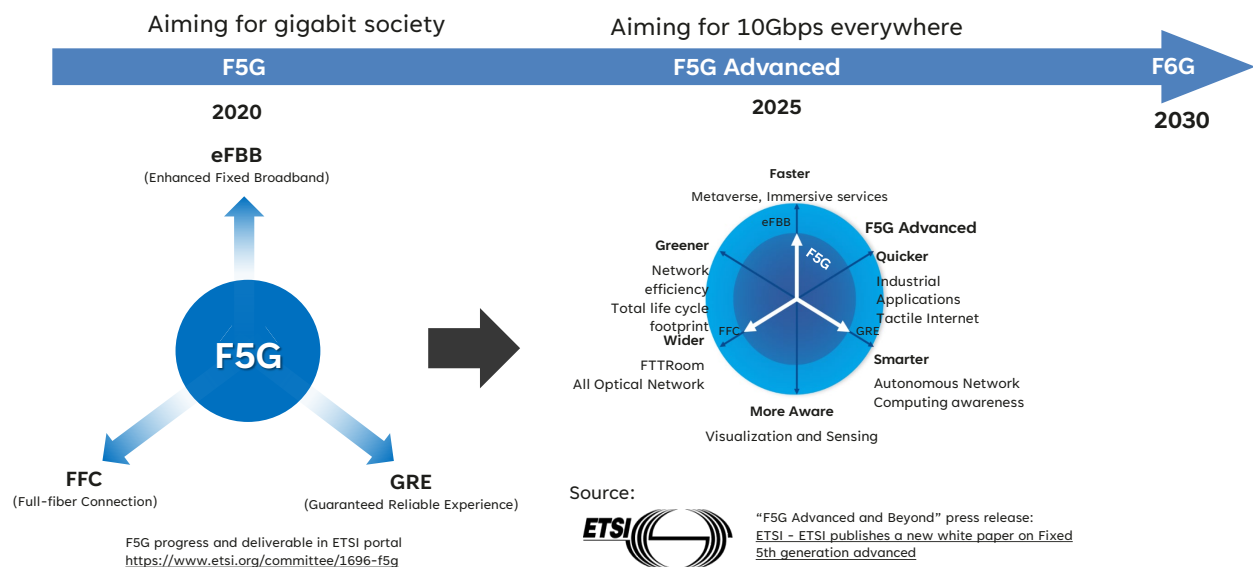


Figure 11. F5G Excellence/Source: ETSI.

Currently, based on Omdia FDI, only one-third of countries to have FTTH coverage rates of 70% or more, whereas only three countries (Qatar, Singapore, and South Korea) reach 100%, and the other three (China, Japan, and UAE) at 99%.

Countries which are one third from the bottom of the index have coverage rates less than 25%, and 18 of 93 countries less than 10%. FTTP coverage in Indonesia is 62% with 12% of penetration rate in 2023. According to data from FDI, to develop a giga society, both FTTP penetration and coverage need to be intensified.

FTTH coverage vs. penetration, January 2023

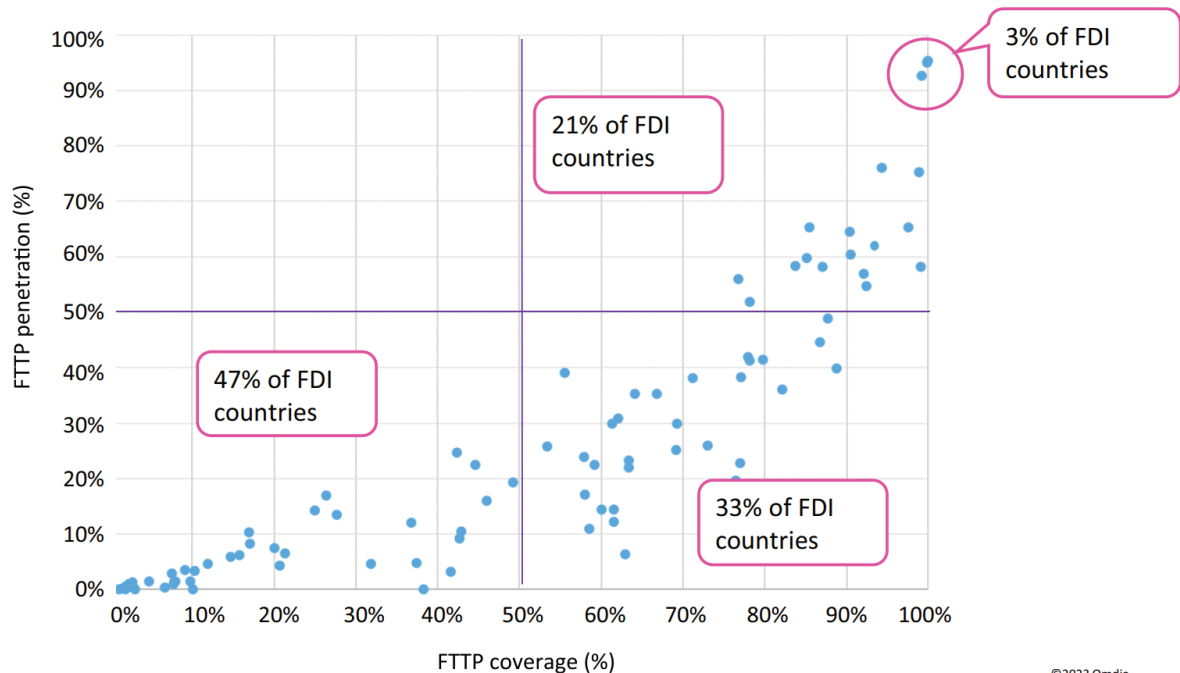


Figure 12. FTTH coverage vs penetration, January 2023/Source: Omdia.

©2023 Omdia

6.3. Challenges in Indonesia Digital Giga City Infrastructure

As the largest country in Southeast Asia, fiber optic penetration in Indonesia has not optimum yet, according to Omdia report. The penetration rate in Indonesia is still low, yet can be improved in various ways, such as collaboration between the private sector and local governments in providing a reliable digital infrastructure network, in sharing passive infrastructure such as poles and ducting, etc.

Further, Indonesia government need to take action by aligning policies of central and regional governments, which is currently not optimal. Alignment between the goals of central and regional governments will create a better infrastructure network.

Currently, Surabaya City Government is implementing administrative sanctions and action to cut off fiber optic cable for not paying rental fees to the city government, which could hamper the digital transformation. Conditions like this will trigger the internet price even more expensive, which then will lower internet penetration in Surabaya.

Besides Surabaya, some other local governments also implement regulations that conflict with the government vision and mission to encourage the

acceleration of digital transformation by providing connectivity.

Local regulation of Mojokerto city, PERDA 10/2011 was amended with 16/2019 about Particular Permit Retribution, which emphasizes that retribution subject is an individual or entity who gains building construction permit from local government. Then, Article 9 Paragraph (3) of the regulation imposes building infrastructure levy tariffs, include excavations of underground utility construction (piping, cable poles, fiber optics, etc.).

Then, governor regulations of DKI JAKARTA PERGUB 106/2019 about SJUT Implementation Guidelines force each provider to place its utility network in an Integrated Utility Network Facility (SJUT), where the costs of relocating the utility network are borne by the telecommunications operator.

Apart from Jakarta, Surabaya, and Mojokerto, APJATEL also noted that there are 70 Regional Regulations/Mayor Regulations/Regent Regulations/Qonun, which make obtaining permits to deploy telecommunications networks and towers, as vital equipments in the presence of Giga City, become difficult and expensive.

No	City/Regency	Regulation	Problem
1	Padang City	Mayoral Regulation 29/2019: Retribution of Telecommunications Tower Control	<ul style="list-style-type: none"> The calculation to determine the retribution fee does not reflect the direct services costs borne by the local government in controlling telecommunications towers The coefficient index in service use level does not reflect service provided by local government
2	Padang City	Mayoral Regulation 9/2019, second amendment of Mayoral Regulation 4/2013: Instructions for implementing property tax collection for rural and urban areas (Article 2)	<ul style="list-style-type: none"> The calculation to determine the retribution fee does not reflect the direct services costs borne by the local government in controlling telecommunications towers The coefficient index in service use level does not reflect service provided by local government
3	Sijunjung Regency	Local regulation 4/2016, amendment of Local regulation 3/2012: Public service retribution	Number of visits to telecommunications sites 6 times in 1 year is over burden
4	South Solok Regency	Local regulation 4/2018, second amendment of Local regulation 3/2012: Public service retribution (Article 48)	The determination of zone coefficient, tower heights, and building density is not in accordance with the services provided by local government
5	Batam City	Local regulation 5/2016, amendment of Local regulation 9/2011: Retribution of Telecommunications Tower Control in Batam City (Article 8)	<ul style="list-style-type: none"> The calculation to determine the retribution fee does not reflect the direct services costs borne by the local government in controlling telecommunications towers The coefficient index in service use level does not reflect service provided by local government
6	Meranti Island Regency	Local regulation 2/2018, amendment of Local regulation 12/2012: Public service retribution (Article 28)	<ul style="list-style-type: none"> The calculation to determine the retribution fee does not reflect the direct services costs borne by the local government in controlling telecommunications towers The coefficient index in service use level does not reflect service provided by local government
7	Central Bangka Regency	Local regulation 1/2017, third amendment of Local regulation 1/2012: Public service retribution	Number of visits to sites 9 times in 1 year is over burden
8	Cirebon Regency	Local regulation 2/2017, amendment of Local regulation 8/2011: Telecommunications Tower Control in Cirebon Regency	The tower height coefficient index is not in accordance with the circular letter
9	Pati Regency	Local regulation 10/2016: Telecommunications Tower Control	Monitoring evaluation 9 times per tower per year is over burden, and coefficient index exceeds total classification
10	Purbalingga Regency	Local regulation 1/2019, amendment of Local regulation 7/2012: Retribution of Telecommunications Tower Control in Purbalingga Regency	Tariff calculation coefficient is not in accordance with the circular letter

Figure 13. 10 of 70 local government regulations, challenge in fiber optic penetration /Source: APJATEL.

The next challenge concerns about initial implementation costs which is very high through space rental revenue or cost sharing, or sometimes both. The deployed fiber optics sometimes encounter some disturbances due to underground cable work. The issue of privatization is also an obstacle where some property developers only allow specific providers they have collaborated exclusively, or subsidiary companies to deploy internet in their area. This privatization also occurs in state-owned companies.

Meanwhile, according to GLG (Gerson Lehrman Group), an independent consulting company, fiber optic developers face different problems. Citing the report entitled Adoption of Optical Fiber in Real Estate Areas, Indonesia market encounter problems regarding fiber optic management as well as operational regulation and governance. Regrettably, it has not been resolved properly, until stakeholders carry out some discussions to resolve it.

- 1 Decision making process of FTTH operators selection is informal and unregulated
- 2 Operators' deployment and management cost on FTTH is very high. However, to win more market share, operators must continue negotiate with property developers to solve the issues
- 3 Property developers have various challenges managing the selected operators
- 4 Operator competition is fierce but unregulated. Operators rely on the relationship and negotiation with property developers to win the market
- 5 Policies are yet to be in place to support the long term development of FTTH in Indonesia

Figure 14. Problems faced by operators in fiber optic deployment/Source: GLG Report (2022).

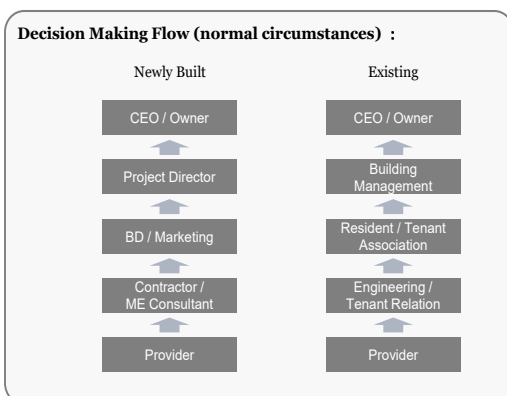


Figure 15. Flow of decision making for new vs existing properties/Source: GLG Report (2022).

Since different property developers have different decision-making processes, there are no one-integrated policy and principle to manage the mentioned problem, which causes unclear and in-efficiency decision making process and also makes operator difficult to manage.

Since it is hard to define the timeline of decision making, it may extend the delay time varies from 2 months to 1 year. In fact, the decision-making process is usually faster for newly built properties, yet slower for existing properties.

Running and managing FTTH is another problem between developers and operators. In some cases, conflicts arise in operating and managing FTTH for long term which impacting end user experience.

Operators and developers have different perspectives. For example, in deploying services, operators focus on initial deployment and high investment cost, so they have to estimate revenue accurately. Fiber backbone to buildings require burial deployment, which is more expensive than aerial.

Whilst, developers perceive that FTTH operators oblige them with minimum 1 year subscription guarantee, which means that operators "charge" the deployment cost and initial investment to developers.

Operator Perspectives

- Huge initial deployment and investment cost – need accurate forecast on subscription revenue, otherwise the breakeven period can't be estimated correctly
- The fiber backbone route path to the building requires underground deployment is more expensive than aerial deployment
- High amount of revenue sharing or space rental fee – can be up to 25% for multi-operators and up to 40% for exclusive operator
- Some operators double count both on revenue and space rental fee
- The underground fiber network is always close to gas, water, and electricity pipes, and thus easily damaged by other pipes' repair. However, other utility vendors seldom notify fiber operators on the repair. The fiber damage always cause high repair cost
- Operators have to keep the pace quickly to catch up with construction progress for newly built properties
- For existing properties, operators' deployment difficulty and cost increase due to existing operators

Developer Perspectives

- Some leading FTTH operators (e.g. Telkom Indihome) require developers to provide a minimum subscription guarantee for 1 year – meaning that operators "pass" some initial deployment and investment cost to developers
- During fiber operation and management, the revenue sharing data provided by the operators is unclear and difficult to trace. Developers need additional time and cost to validate the data
- For existing properties, there is infrastructure compatibility and legacy issues or insufficient space in the shaft network room. Operators need to renovate the existing infrastructure, therefore existing properties cant easily attract fiber operators

Figure 16. Operator and developer perspectives/Source: GLG Report (2022).

The large number of fiber optic operators in Indonesia is a problems itself. Tight competition without good industrial governance causing chaos in market supply.

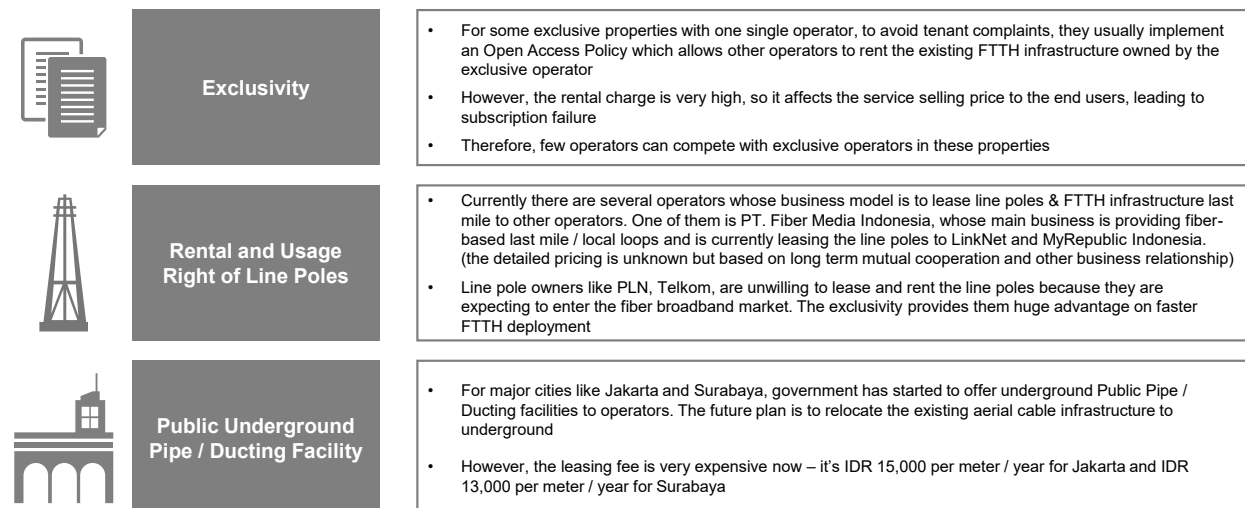


Figure 17. Challenges in deploying fiber optics/Source: GLG Report (2022).

With all these issues, at the macro level, operators in Indonesia need to collaborate with various associations to find a middle way and mutual-benefit FTTH solutions. From operational perspective, they need to improve relationship more closely with property developers and other stakeholders.

Furthermore, GLG also recommends some solutions to overcome the problems in deploying fiber optics in Indonesia, as follows:

- 1 Operators need to participate more in activities of different property developer stakeholders, e.g. REI (Real Estate Indonesia), APERSI (Asosiasi Pengembang Perumahan & Permukiman Seluruh Indonesia), ACE Indonesia (Asosiasi Chief Engineering Indonesia) and etc., to enhance the brand awareness and advocate the overall FTTH discussion
- 2 Operators shall work closely with telecom and network related associations to advocate the FTTH discussion, including APJATEL (Telecommunications Network Operators Association), APJII (Indonesian Internet Service Providers Association) and MASTEL (Indonesian Telematics Community) - the three associations with closest industry relationship with the government
- 3 Together with the 3 key associations (APJATEL/APJII/MASTEL), operators can consider submit the review request to the KOMINFO and KPPU (Commission for the Supervision of Business Competition) on the exclusive line pole status of Telkom and PLN
- 4 There are currently no fixed & written regulations from the governments of the FTTH adoption. Operators shall proactively approach the property developers, especially those Mid-High end developers
- 5 Operators shall consider cooperating and partnering more with other stakeholders, e.g. other operators, system integrators, IT solution contractors, etc.

Figure 18. Recommendations to resolve problems in fiber optics deployment/Source: GLG Report (2022).

6.4. Digitalization Prospective in Surakarta City

Surakarta City covers an area of 46.72 km² with a population of 523,008 people (2022). Surakarta has 54 subdistricts (kelurahan) which are divided into 5 districts (kecamatan), i.e. Laweyan, Serengan, Pasar Kliwon, Jebres, Banjarsari. The Regional Gross Domestic Product keeps growing on average 5% per year which reached Rp 55.96 Trillion in 2022. The figures show that Surakarta City has considerably potential for economic growth in the future. It is also supported by availability of adequate facilities in Surakarta, in terms of education, health, industry, trade, financial institutions, tourism, transportation, and worship facilities.

Educational facilities in Surakarta are available from elementary school to higher education (university). The number of educational facilities at each level, health facilities, hotels, tourist visits, industry and trade facilities as shown below. These sectors are the main concern of Surakarta City mission. In particular, some places are tourists main destination (tourist attractions), such as Baluwarti Cultural Site Village, Kethoprak Balekambang, Kasunanan Palace, Mangkunegaran, Radya Pustaka Museum, Balekambang Park, Wayang Orang THR

Sriwedari, Danarhadi Batik Museum, Solo Safari Zoo, Keris Museum, and Lokananta Museum.

In order to boost the quality of education, health services, industry, trade, and tourism, obviously require a seamless information and telecommunications technology support. Telecommunication devices play an important role for the future technology development. The need for informatics and telecommunications devices such as laptops, controlling devices, gateways, routers, fiber optics, etc. continues to increase in the future. Furthermore, the agricultural sector gets the benefit from Wireless Sensor Networks (WSN) to monitor plant conditions, the health sector also uses it to monitor patient conditions. Then, Virtual Reality (VR) can be used in the health sector as a training tool and simulation for medical surgery; Augmented Reality (AR) can be used in the education sector; Radio Frequency Identification (RFID) which is widely used in the manufacturing industry; Internet of Things (IoT) to support the implementation of smart cities and smart homes; as well as Artificial Intelligence (AI) to support increased productivity in various fields and automated cars obviously require a strong information technology and telecommunications support.

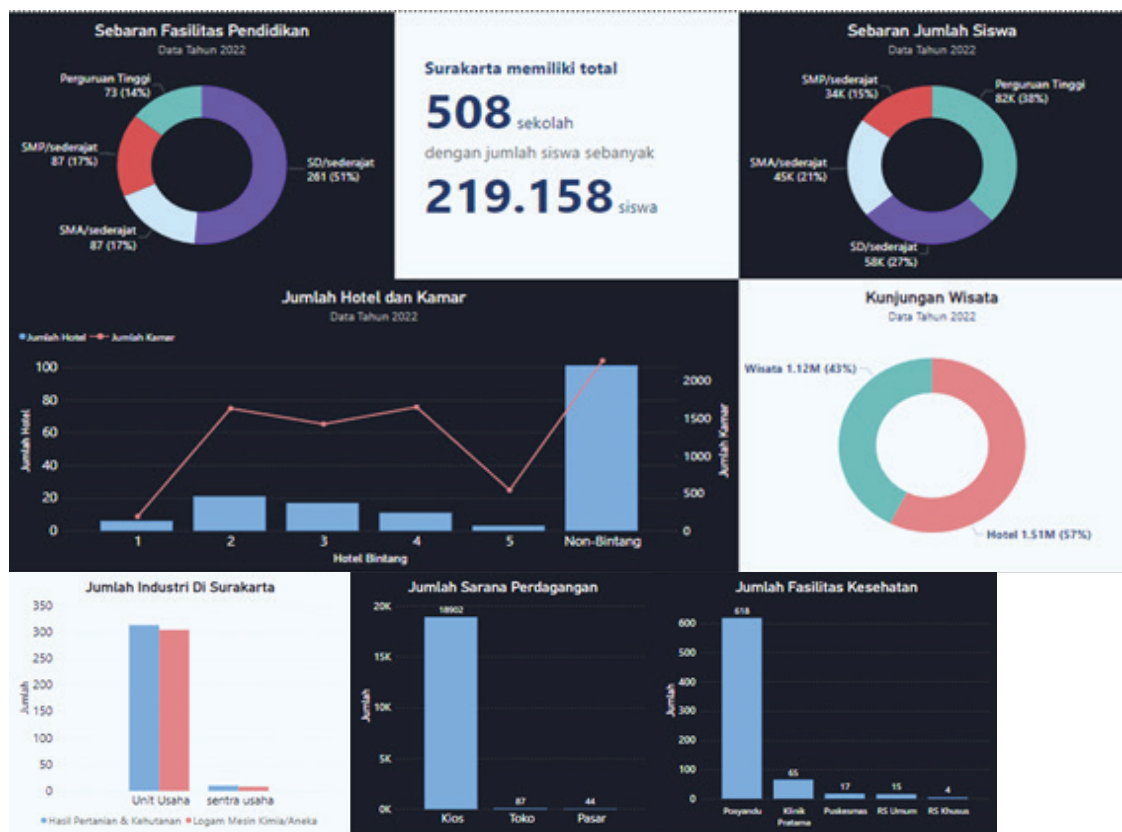


Figure 19. Number of public and commercial facilities in the City of Surakarta/Source: BPS Surakarta, Surakarta in Numbers (2023).

To manifest a seamless information and telecommunications technology support, digitalization is necessary in various sectors to increase productivity and work efficiency. And to boost digitalization and accelerate digital infrastructure development, implementing a super-fast network called "gigabit" is a must. The existence of a gigabit network allows Indonesia to adapt future technologies such as the Internet of Things (IoT), big data, Virtual Reality (VR), and Augmented Reality (AR), which require a high capacity and high speed internet network. Currently, some cities worldwide and in Indonesia are planning to develop gigabit networks. Three essential points need to be considered to achieve optimal gigabit network, which are gigabit infrastructure development towards the realization of Giga City; creating demand from end users, households, government institutions, and private sector; also creating knowledge, skills, and experience to facilitate people in using gigabit technology.

As an example, Thailand is building a smart city designed with a very clear Giga City pyramid strategic plan, implementing full fiber optics and 5G infrastructure. The implementation of full fiber is already started in large cities (Giga Cities Initiative) by implementing four supporting policies: infrastructure sharing, fiber pre-deploy, Universal Service Obligation (USO) funding, and broadband monitoring. Infrastructure sharing aligning policies between central and local

governments therefore the infrastructure can be utilized optimally. Besides, central government, especially Kominfo, plays a significant role to encourage the availability of excellent infrastructure and gigabit connectivity technology in terms of quality and speed.¹⁶

The availability of infrastructure and technology supporting gigabit networks is expected to meet the criteria desired by users. This criteria is the availability of a gigabit network with high speed and low latency, so the users can enjoy a fast and safe internet access experience in their activities. Meanwhile, from the company or corporate user perspective, the gigabit network is expected to be an enabler to boost productivity in various sectors such as industry, trade, and tourism. Further, gigabit networks are also needed to support activities in the education, health, and other social activity sectors.

To encourage optimal gigabit network deployment, a long-term strategy is needed which involves contributions from various parties, from the government to the telecommunications industry. Some countries, such as Thailand and China, are in the process and succeeded in implementing gigabit networks. With its fiber and IPv6 technology, Indonesia can learn from Thailand for benchmark.

¹⁶ Buletin Digital 2045

The background is a dark blue gradient with abstract geometric patterns. It features several interconnected nodes (small circles) and lines, creating a network-like structure. There are also some larger, semi-transparent blue shapes, possibly representing buildings or data clusters, scattered across the frame.

7

Indonesia Giga City, Implementation and Initiative

7. Indonesia Giga City, Implementation and Initiative

7.1. Mobile and Fixed Broadband Networks in Surakarta City

7.1.1. Mobile Internet Coverage

Many internet service providers operate in Surakarta to support the increasing need of internet connectivity. They offer various internet services based on technologies and speeds that keep individual and business users stay connected. There are four providers in Surakarta: Telkomsel, Indosat Ooredoo Hutchison, Smartfren, and XL Axiata. It shows that competition for mobile internet providers is still open and not dominated by just one or two players.

4G and 5G internet coverage from the four

providers is shown in the figure below. All providers have provided 4G services that reach all areas in Surakarta at the coverage level 100%. However, for 5G services, no provider covers the area 100% yet. Telkomsel with the new 5G signal covers 20.4% in 11 subdistricts (kelurahan). Meanwhile, Indosat Ooredoo provides 5G services with coverage rate reach 80%. XL Axiata with 4G internet service covers 54 subdistricts in Surakarta or 100% coverage. However, XL Axiata 5G service is not available in Surakarta, nor is Smartfren.

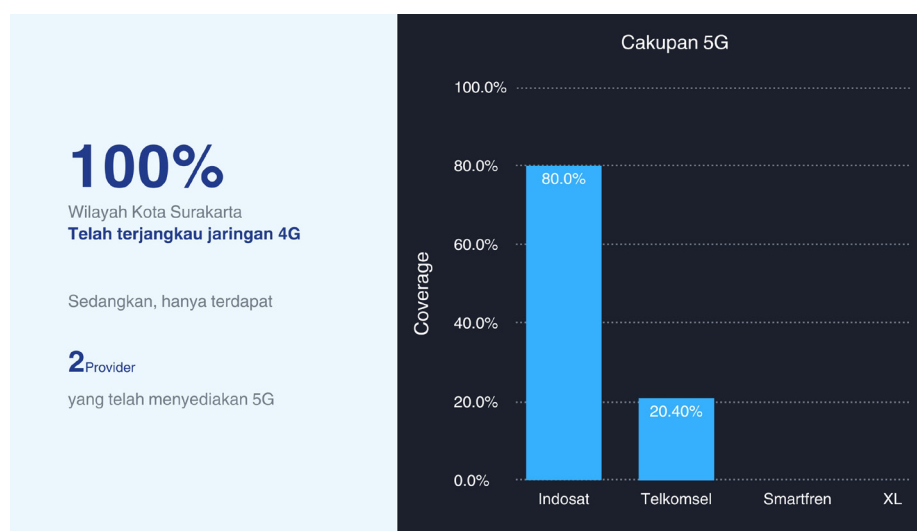


Figure 20. Internet service coverage in Surakarta City/Source: Provider official website (2023)

Mobile internet speeds in Surakarta reaches 23 Mbps for media download speeds, while media upload speeds reaches 18.7 Mbps.¹⁷ It shows that internet speed in Surakarta is still low and far from other big cities in the world such as Dubai which reaches 255 Mbps, and Beijing at 241.8 Mbps.¹⁸ Obviously, this is a challenge for providers and Surakarta City government to improve existing facilities so the internet speed can be amplified for the community.

¹⁷ <https://www.speedtest.net/performance/indonesia/central-java/surakarta>

¹⁸ <https://www.speedtest.net/global-index>

7.1.2. Fiber Optic Internet Coverage

For fixed broadband or internet network coverage via fiber optic, service providers available in Surakarta are Citranet, Biznet, Iconnet, CBN Fiber, My Republic, First Media, and Indihome. This fact shows that competition for fixed broadband services is still relatively healthy because not dominated by just one or two providers. Fixed broadband coverage for each provider in Surakarta, referring to the number of sub-districts served, can be seen in the figure below.

Based on the percentage of fixed broadband coverage, it is divided into two categories i.e.

providers with coverage above 50% and ones below 50%. Provider with more than 50% coverage are Indihome at 94.4% coverage, covers 51 of total 54 subdistricts in Surakarta; Biznet has 92% coverage, covering 50 subdistricts; CBN has 66% coverage, covering 36 sub-districts and Citranet with 51% coverage, covers 28 subdistricts. Meanwhile, provider with coverage below 50% is First Media, has coverage of 46.3%, around 25 subdistricts; My Republic has 27.8% coverage, covering 15 subdistricts; and Iconnet with 18.5% coverage, covering 10 sub-districts.

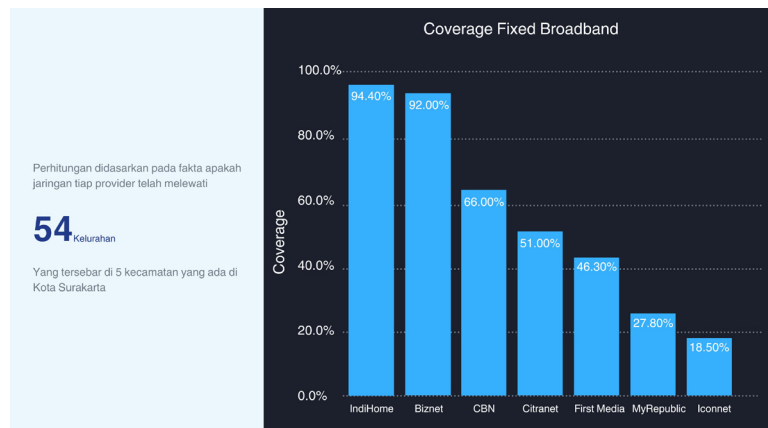


Figure 21. Fixed broadband coverage in Surakarta City based on provider/Source: Provider official website (2023).

Meanwhile, data providers, bandwidth, and prices charged to fixed-line users can be seen in the figure below. Referring to the bandwidth graph offered by each provider, the bandwidth offered is still limited from 10 Mbps to 1 Gbps with prices between Rp189,000 to Rp3,999,900. Most users of fixed broadband internet access are households, schools, hotels, restaurants, offices, hospitals, companies, and others. Indeed, some providers offer bandwidth up to 1 Gbps, but the prices are still very high. This is a challenge for providers and local government to implement Giga City as a supporting system for smart cities like other Giga Cities in the world, such as Abu Dhabi and Beijing, with broadband access speeds above 260 Mbps.¹⁹

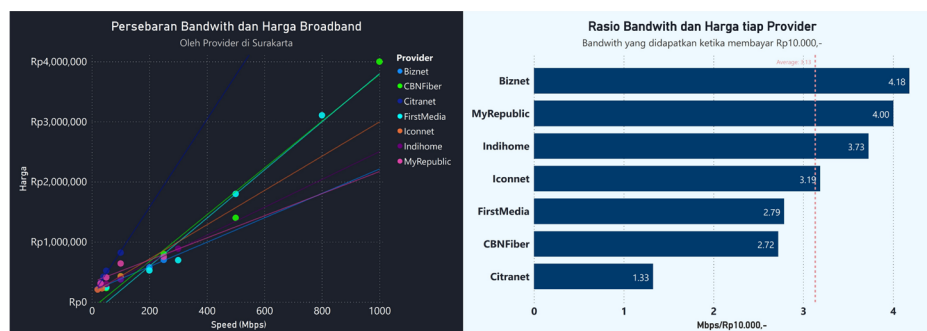


Figure 22. Bandwidth and price graph for each provider/Source: Provider official website (2023).

When installing a fiber to the home (FTTH) network, each provider still utilizes its own route at the same location as other providers. This condition is as described by Gerson Lehrman Group (GLG) in its report, where some property owners uphold the principle of exclusivity to avoid tenant complaints. Even if the property owner opens it to another operator, they will apply expensive fees.

This condition must be regulated to make the installation neater and safer from fire risks. In the meantime, the Surakarta City government needs to formulate local regulations that manage the installation of fiber optic poles and cables, and encourage pole sharing mechanism among providers.

¹⁹ <https://www.speedtest.net/global-index>



Figure 23. Appearance of fiber optic cable installation/Source: Google.

7.2. Surakarta City Digital Vision and Plan

Surakarta City considers fiber optic infrastructure is vital to support the vision of "Realizing Surakarta as a Modern, Resilient, Agile, Creative and Prosperous Cultural City." The Surakarta city government formulated a policy direction: "Making Surakarta A Modern, Resilient, Agile, Creative and Prosperous Cultural City".²⁰ The Surakarta City government formulates policy direction as "incorporating Javanese culture values into system integration towards sustainable smart city development". Refer to its vision and policy direction, Surakarta City endeavor to present a smart city, though not yet considered in IMD Smart City Index 2023.²¹

Mission

- First**, improving sustainable community health
- Second**, strengthening an adaptive and sustainable economic growth
- Third**, creating city spatial planning and infrastructure that support culture and tourism
- Fourth**, improving quality and competitiveness of youth and society in education, economics, arts, culture and sports
- Fifth**, developing agile and collaborative governance and public services based on the spirit of mutual cooperation and diversity
- Sixth**, creating fair and inclusive prosperity and welfare for the citizens
- Seventh**, creating conducive and inter-religion harmony communities with mutual respect

Figure 24. Surakarta City Mission/Source: Website Surakarta City.

This vision and policy direction are translated into seven missions of Surakarta City. The first mission focuses on smart living, improving sustainable community health. The city of Surakarta wants to improve quality standards and equalize health aspects. This can be demonstrated from placement of local hospitals, 17 community health centers, and the local health laboratory and pharmaceutical installations. Most of them have already applied digitalization for their customer service.²² Like the Regional Public Hospital RSUD dr. Moewardi and several community health centers have provided online services.

The second mission relates to the smart economy: strengthening an adaptive and sustainable

economic growth. Surakarta is increasing attractiveness by revitalizing several parks and road access, such as the Batik Village and Solo Safari. Furthermore, the local government is aggressively encouraging the development of micro, small, and medium enterprises (MSMEs) through training and digitalization carried out together with Financial Services Authority (OJK), Bank Indonesia (BI), and private companies (Gojek).^{23,24} The application of digitalization aspect is also carried out by the local government to invite investors. It is proven in the investment indicator, that the annual investment target was already achieved 90.99% in the first half of 2023, showing the enthusiasm of investor coming to this city.²⁵

²⁰ Peraturan Daerah Kota Surakarta Nomor 6 Tahun 2021 tentang Rencana Pembangunan Jangka Menengah Daerah Tahun 2021-2026

²¹ <https://imd.cld.bz/IMD-Smart-City-Index-Report-20231>

²² <https://surakarta.go.id/?p=26940>

²³ <https://bisnis.solopos.com/siap-naik-kelas-50-pelaku-ikm-solo-digembleng-jadi-calon-eksportir-pemula-1637852>

²⁴ <https://www.cncbindonesia.com/entrepreneur/20230818163543-25-464172/goto-ajak-ratusan-umkm-meriahkan-hari-umkm-nasional>

²⁵ <https://www.facebook.com/p/dpmpptsurakarta-100069907410740/>

The third mission is to create city spatial planning and infrastructure supporting tourism, to promote sustainable culture, or to focus on smart living and environment. For traffic management, CCTVs are installed to monitor road conditions directly. As for the fiber optic infrastructure aspect, underground cable (ducting) construction will be continued. The ducting cable network still needs to be improved on a few roads, such as Slamet Riyadi Street and Adi Sucipto Street.²⁶ Clean water management is also a concern of the Surakarta City government to reduce slum areas. Drinking water from pipes in this city is already at 50% (far above the national average of 20%). Still, it will be continued to be until reaching 90% like Malaysia through the USAID IUWASH Plus program.

The fourth mission focuses on smart people, which is "Improving the quality and competitiveness of youth and society in education, economics, arts, culture and sports". The mission can be done through digitalization of the education quality, both non-formal and formal. The aspect of literacy culture is also enhanced through collaboration with the arts and culture community in Surakarta to revitalize ancient manuscripts.

The fifth mission is "Developing agile and collaborative governance and public services based on the spirit of mutual cooperation and diversity". This mission focuses on the aspect of smart governance that encourage the digitalization of government and public services. 97% of regional apparatus own independent websites where 85.37% are already integrated with e-governance.²⁷ Refer to the aspect of public services, Surakarta citizen enjoy the convenience of digital services through the website or mobile application created by Diskominfo Surakarta, named Ringkes. People can take the online queue for services at MPP Jendral Sudirman, Surakarta City.

The sixth mission is "Creating fair and inclusive prosperity and welfare for the citizens" along with the seventh mission "Creating conducive and inter-religion harmony communities with mutual respect", which focus on smart living aspect by providing livable houses and personal security. In 2022, there are 47 livable houses were built in the area of RW1 Mojo Subdistrict in order to reduce slum areas and provide shelter for less fortunate residents.²⁸

In the meantime, institution partners of Surakarta city government are already in the same direction to support smart city implementation. From education sector, Sebelas Maret University (UNS)

stands out with its integrated access to information through <https://smartin.uns.ac.id> platform. UNS own an integrated system consist of planning, finance, academics, and student services. The university actively publishes on social media such as Instagram, YouTube, and websites, which reflects its commitment to be at the forefront of digitalization. Working units under UNS also contribute to digitalization endeavours. Next, state senior high school SMA Negeri 1 Surakarta develops website, e-learning, digital library, and computer-based exams. State junior high school SMP Negeri 4 Surakarta also utilizes various digital platforms to publish its activities and provides information to support teaching and learning activities via the website. It also has language lab and e-learning system, and e-library that allows access to digital resources. State elementary school SD Negeri Mangkubumen Kidul 16 is active in publications on YouTube and has a literacy program.

The health sector in Surakarta City is also implementing smart hospital concept, which prioritizes digitalization and information technology. RSUD Dr. Moewardi has adopted digitalization on website, enabling online booking, and delivering essential information. They create applications, such as e-medical records, e-patient, e-doctor, e-employer, Integrated System for Resolving Complaints (Singa Teriak), Integrated System for Emergency Referrals and Home Visits (Si Jaga Dara), Self Registration Platform of Geriatrics, Obgyn, and Pediatrics (Apem Gerobag), and Assessment and Intervention Application (Siansi). Jogja International Hospital (JIH) Surakarta own a website and mobile application for patient services. They allow consultations via WhatsApp. This initiative proves that health services in Surakarta have led to smart city realization.

In the arts sector, Batik Keris has a mission to introduce culture yet keeping up with the modern era. Besides active promoting culture through online platforms such as websites and social media, especially Instagram, Batik Keris also collaborates with local artists to create batik designs that combine traditional elements with a modern touch. Meanwhile, Laweyan Batik Village is encouraged to upgrade business skill in management and product promotion on digital media through Laweyan Digital Village Program launched by IndiHome Telkom Indonesia. Through this program, local entrepreneurs get trained on accounting and digital marketing to develop their business. This transition not only contributes on cultural diversity, but also gives opportunities for local artists to grow and participate in building a sustainable smart city.

²⁶ <https://dprd.surakarta.go.id/komisi-iii-usulkan-ducting-kabel-bawah-tanah-dimasukan-di-raperda-pengelolaan-sistem-drainase/>

²⁷ Peraturan Daerah Kota Surakarta Nomor 6 Tahun 2021 tentang Rencana Pembangunan Jangka Menengah Daerah Tahun 2021-2026

²⁸ <https://ekonomi.bisnis.com/read/20221118/47/1599897/smf-bangun-47-rumah-baru-mbr-di-surakarta>

Meanwhile, Surakarta's traditional markets still need to uplift the utilization of digital technology. Internet infrastructure, fiber optic, and wireless must be improved. In the modern store, Solo Paragon Mall has provided WiFi access, though the mobile application is inactive. They are active on Instagram and support digital payments. Indeed, there is opportunity to develop concrete programs supporting the environmental sustainability vision.

In hotel and restaurant sector, Hotel Alila offers assorted facilities, such as aerobics training, spa/wellness packages, swimming pools, and free WiFi access. They also provide information on their own personal website. Diamond, Orient, and Kusuma Sari restaurants offer WiFi access, online reservations via telephone or WhatsApp, and even food ordering via applications such as GoFood and ShopeeFood. They are active on social media such as Instagram and have digital menu which allow customers to view the menu online.

Looking at this progress, Surakarta City is advance to become a smart city with strong digitalization endeavours in many sectors mentioned. However, these efforts require fast and stable internet access which need support in infrastructure such as fiber optic networks.

The Surakarta city government has initiated collaboration with many stakeholders in piloting the Giga City connectivity technology model to provide a digital experience of ICT infrastructure in the future towards Golden Indonesia 2045.²⁹

7.3. Fiber Optic Policy Optimization

Giga fiber optics presence are crucial to support digital transformation, as explained in the mentioned examples, either applied in Indonesia cities or foreign countries. Fiber optic infrastructure can transmit high speed internet which will accelerate the transformation.

However, the problem that often occurs is overlapping pole to drape fiber optic cables. Each company wants to use its own pole which creates a stack of 3-4 poles in one location. This impacts the higher costs in deploying fiber optics and a longer deployment time to the market.

To optimize the fiber deployment in supporting digital transformation, APJATEL proposes pole sharing mechanism. Fiber optic cables belong to private or state owned companies can be placed on the same pole to make it more efficient and keep the city layout neat. Also, the aerial cables that previously hanging in the air and looked agitating, can be placed underground using a common ducting scheme.

The Depok and Bogor City Governments, in collaboration with APJATEL, are implementing this policy, tidying up fiber optic cables in the air to maintain aesthetics and public safety. Cable relocation was carried out gradually in stages, where Phase I was executed in 2022. At Siliwangi Street there were 7 of 31 aerial cables belong to operators. The cable was relocated and placed in a shared underground passive infrastructure (ducting).

The installation of passive underground infrastructure is 100% completed, ready to accommodate cable relocation from aerial to underground. The relocation process also involves Depok City Public Works and Spatial Planning Department (DPUPR) and Development Administration Department, which was completed in March 2023.

Besides giving a more organized impression, utilization of shared ducting has a good impact to operators in cost and time efficiencies. The operators no need to spend costs for excavation because it is already carried out by one vendor.

²⁹ <https://jatengprov.go.id/beritadaerah/gandeng-huawei-solo-jadi-percontohan-giga-city-5g/>

The ducting scheme not only prevails in Bogor and Depok, but also in Bandung. APJATEL supports the relocation process in Bandung City to reduce the risk of cables dangling in the air.

Besides using ducting, cable tidying can also use the criping method by tying all the cables in the air together so the cable remains intact. Then finally, use the integrated utility network (SJUT).

7.4. STP (Solo Techno Park), An Example of Giga Campus

In developing a technology-based city, Surakarta is also preparing a high-tech area called Giga Solo Techno Park (STP) Campus. Giga STP Campus is an industrial area with a Giga connectivity network. The gigabit network technology used at the STP Campus can be applied to 2B and 2H deployment scenarios throughout the city, thereby enabling the transformation of the gigabit network into a Giga City.



Figure 25. 3 scenarios using Giga Network by STP /Source: Solo Technopark.

STP Giga Campus offers three scenarios of giga network utilization. First, giga coverage is everywhere as STP provides a premium network for all active users in the campus. Second, it provides reliable quality connections for big companies, and lastly, it provides full office coverage for SMEs. Then, there is also Fiber to The Room to Building (FTTR-2B) solution to provide Giga campus Wi-Fi coverage for science and technology park.

In introducing the benefits and advantages of giga network, Giga STP Campus held F5G Giga STP exhibition, which presented an Edge OTN fiber connection solution with a stable, reliable, easy to manage and scalable giga backhaul for the campus network. The exhibition showcase the Fiber to The Room to Home (FTTR-2H) solution for giga Wi-Fi office coverage aimed to SME customers. At the STP campus, Huawei uses an innovative Mini Optical Line Termination (OLT) + Digital Quick-Optical Distribution Network (DQ-ODN) solution to support rapid fiber deployment.

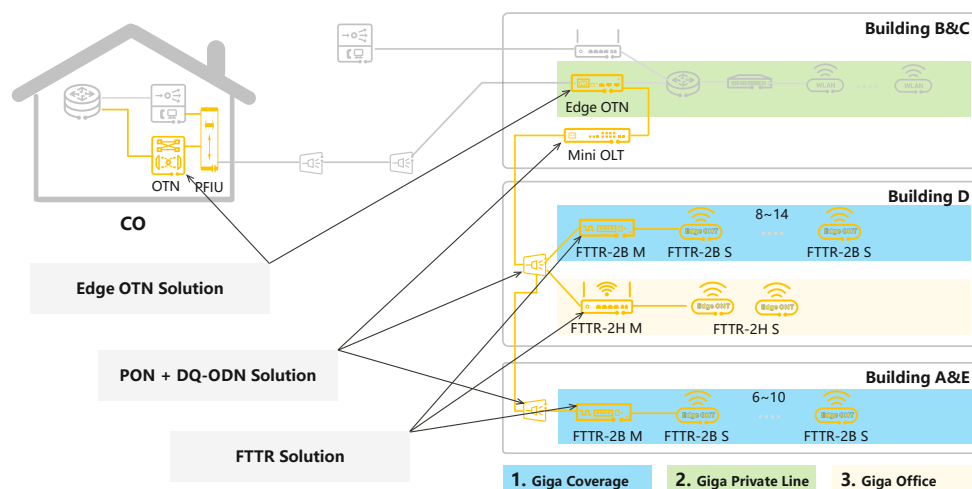


Figure 26. Solutions offered at the STP showcase /Source: Solo Technopark.

In the showcase, Mini OLT is used to deploy a campus Passive Optical Network (PON). Mini OLT supports flexible deployment solutions. Some outdoor OLTs can be installed on walls or poles, and some indoor OLTs can be installed in equipment rooms. Therefore, Mini OLT can run smoothly without configuring a special air-conditioned room. It is ideal for a variety of applications on campuses, communities, and apartment buildings.

The Mini OLT deploy uses XGSPON (10 Gigabit Symmetrical PON) technology, which can smoothly evolve to symmetric upstream and downstream 10GPON (10 Gbps Passive Optical Network) bandwidth. In the future, the campus network can be upgraded to 10GPON without replacing the OLT.

The DQ-ODN solution is used on the campus network. No professional fiber optic splicer equipment is needed nor engineers with specific fiber splicing skills as in traditional fiber optic deployment. All optical cables are already pre-connected and promptly installed on site by trained workers. The solution can increase efficiency significantly in fiber optic deployment and it is applicable not only for campus but also for FTTH in general.

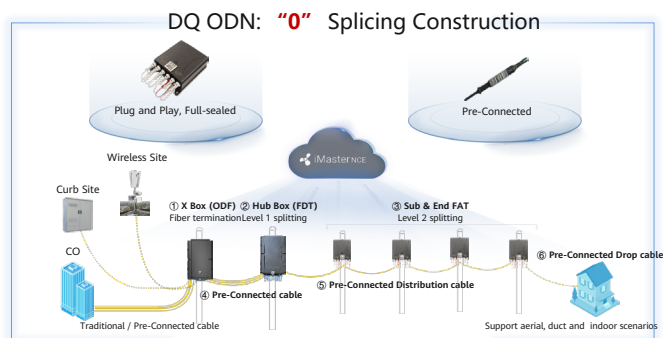


Figure 27. DQ-ODN solution/Source: Solo Technopark.

In the F5G Giga exhibition, STP adopted the industry-leading FTTR solution to overcome poor indoor Wi-Fi coverage. Fiber to The Room (FTTR) connects primary/secondary devices to Wi-Fi network by deploying fiber optics to each Wi-Fi access point.

People can enjoy giga coverage everywhere and seamless Wi-Fi roaming. FTTR uses two solutions for different scenarios in STP Showcase. The FTTR-2B solution is suitable for big enterprises or campus networks which can provide up to 32 Edge ONT (Optical Network Terminal), which is applicable for wide-ranging areas and reach a large number of users.

The Edge ONT FTTR is installed in the ceiling. Another solution is the FTTR-2H, targeting SMEs and regular home users, suitable to cover multiple offices or rooms. The device is compact, attractive and can be placed on a desktop.

7.5. Giga City Fiber Optic Development

The Indonesian government goals are to increase competitiveness and digital impact through digital infrastructure in regional and global scale. Indonesia has medium-term national plan and Indonesia Digital Vision (VID) 2045 to achieve the goals.

Furthermore, by interpreting VID 2045 Framework and benchmarking to other countries development journey, the government plan to deploy Giga City backbone connections as a guidance for digital infrastructure development and drive the country towards Digital Vision in RPJMN 2025-2029.

To guarantee fiber optic development proceeds effectively and in line with national digital development goals in Indonesia, APJATEL suggest 5 (five) as follows:

1. Continuously measure and monitor development progress using key indicators such as fiber optic penetration, Fiber to The Home (FTTH) coverage rate, fiber to wireless rate, fiber to enterprise coverage rate, etc.

Indicators	Definition	2025	2030	2035	2045
Fiber Optic Penetration	Percentage of areas connected to the FO network	20%	40%	65%	90%
Fixed broadband Penetration to Households	Percentage number of customers fixed broadband per household	26%	50%	75%	100%
Fiber Optic Households Coverage	Percentage of households covered by the FO network	60%	70%	80%	98%
Fiber Optic Wireless Sites Coverage	Percentage of Wireless Sites covered by the FO network	40%	80%	95%	100%
Fixed broadband Download Speed	Ookla Fixed broadband Download Speed	80M	200M	500M	5G
Giga City Numbers	Giga City Criterion (Urban Giga fiber coverage: > 80%, Percentage of Giga users: > 25%, Percentage of 10G-PON ports: > 25%)	5	30	100	200

Figure 28. Recommendations for fiber optic development program indicators/Source: ITB (2023).

2. Set up various targets for fiber connectivity that enable domestic competitiveness. Select target cities wisely to lead and accelerate the overall target accomplishment. Arrange Top 30 Cities indicators which is compared with global target.
3. Implement nation-wide program for fiber optic development with Giga City Lead, USO Balance. Set up the guidance of Giga City campaign indicator to promote the Top 30 Cities in urban areas to achieve world-leading infrastructure. Then, promote all the innovation and industry digitalization improvement in the infrastructure sector.

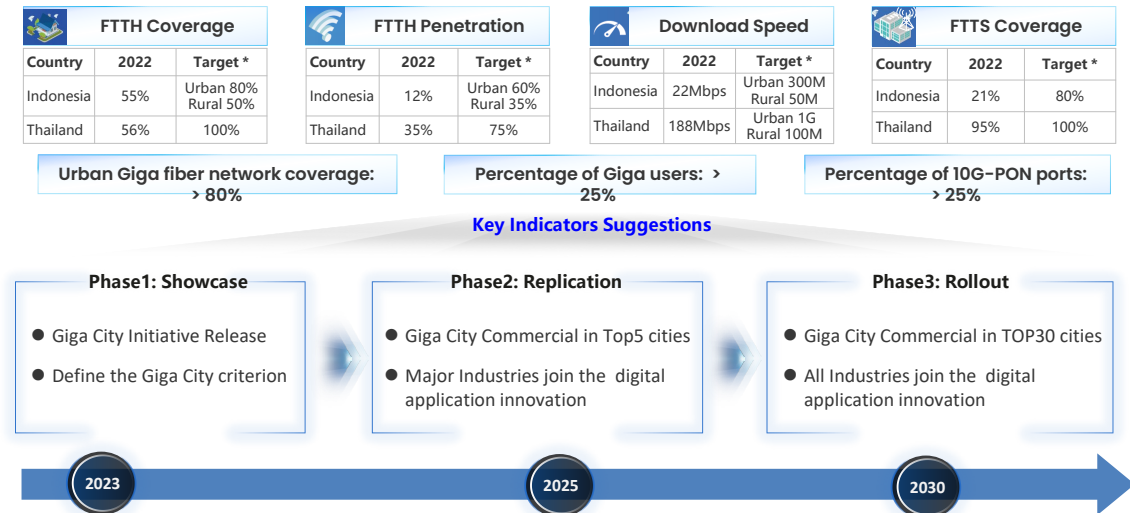


Figure 29. Recommendations for the national fiber optic development program/Source: ITB.

4. Implement a long-term national development commitment by adopting a 20-year guideline index. Within 20 years most cities in Indonesia will be considered in the Giga City category, where vital cities will reach 10/100Gbps. Extensive coverage of broadband connectivity enable and stimulate digital application innovation in various industries. Like happening in digital application innovation event "Guanghua Cup" China in 2023, successfully innovate more than 17,000 new applications thanks to giga infrastructure existency.
5. Award subsidies to support basic connectivity and resolve digital infrastructure gap in suburban and rural areas.

Furthermore, based on a survey conducted by APJATEL regarding fiber optic development in Indonesia, there are a number of challenges in fiber optic development which must be resolved together. Those challenges are as follows:

1. Difficulty to get Right of Way (RoW), specifically for public and some exclusive private area.
2. Duplication of investment. Every operator requests its own RoW and install poles in the same locations with other operator.
3. Low efficiency in implementation. Currently, connecting fiber optic onsite require skilled technicians, and reliable but unaffordable equipment.

Therefore, APJATEL recommends a policy that regulates and accelerates fiber deployment in Indonesia. This policy focuses on things as follows:

1. Define RoW and optimize approval procedures to eliminate Implementation barriers. Also need to simplify SLA, implement one stop agreement, and lower rental fee.
2. Implement innovative solutions by adopting new technologies such as Quick-Connect/Pre-Connect solutions, to overcome the high costs of time and money when using traditional solutions.
3. Infrastructure sharing, such as pole sharing for aerial cable deployment can make fiber optic rollout more efficient. Duct sharing for burial cable deployment can minimize excavation activities and reduce the time to market.



8 | Recommendation

8. Recommendation

All implementation and endeavour undertaken to develop Giga City infrastructure in several cities as mentioned in this white paper, like Surakarta, bring out some important values in governance perspective.

First, role model for nation-wide infrastructure development acceleration. The Surakarta City government carries out various innovations to improve the quality of digital life effectively. The plan on pole and duct sharing mechanism, a win-win solution, led by the government and implemented by local enterprises contribute to local government fiscal growth.

Pole sharing can accelerate the deployment of ICT infrastructure and improve the city competitiveness. Besides, this program make the citizen enjoy a high quality and faster digital services, also capable to be a strong qualified cornerstone for digital transformation.

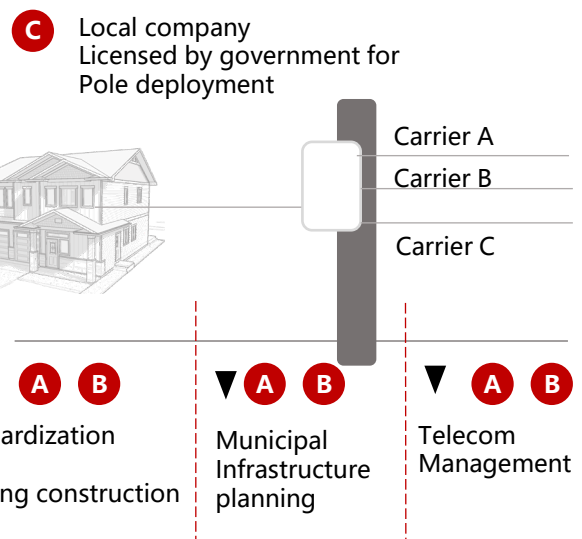


Figure 30. Illustration of best practices in pole sharing.

Secondly, optimize the city planning. Define the responsibility matrix more clearly, make it easier for everyone to carry out their duties. Distribute full responsibility into various departments, facilitate a more professional standards of arrangement in the related government institutions. The placement of pole stations by government based on urban planning guidelines, make it easier to obtain the right of way and speeds up the 'last mile to end user' process.

Thirdly, encourage a healthy market. Infrastructure sharing helps service providers to reduce the total cost of deployment also operation and maintenance, as the basis to give a more efficient network services.

The utilization of multi-operator fiber optic infrastructure is favourable to enrich service options for end user, and optimize resource allocation throughout society. This action can also prevent from investment duplication on social resources (include government and operators). Apply smarter government regulations on market with a visionary outlook.

Fourthly, full scenario exhibition. Create a showcase, a manifestation of Giga City, so people can enjoy the giga era more intuitively. Stimulate governments, communities, companies, and citizens to visualize the future of digital society, and promote digital applications.



Figure 31. Application of giga infrastructure.

Surakarta City has an excellent universal value. In Indonesia, there is only one super city like Jakarta. However, a mini city like Surakarta, which has a population of around 500,000 people, has cultural and tourism characteristics, and good potential to develop digital economy, requires infrastructure modernization. Endeavour and best practice experience undertaken by Surakarta City in developing digital infrastructure should be replicable to other cities in Indonesia.

Best practices in digital infrastructure has the potential to increase employment opportunities. Industrial chains will be optimized, the responsibilities of all parties will be clearer; the allocation of resources will be more reasonable; and the efficiency of urban planning and execution will be improved. The interests of all stakeholders will become more equal, and more high-quality job opportunities will be available in the long term.

Digital infrastructure best practices has the potential to boost investment. Innovative solutions and leading technologies are used to reduce costs, increase investment efficiency, and accelerate deployment, thereby driving the operators to invest. Municipal governments have a clearer workflow from planning to implementation, more people will experience the benefits, and accelerate the urban development. It is necessary to mobilize and activate society to participate in digital infrastructure development, activate market vitality, and reduce operation and maintenance costs.

Digital infrastructure best practices should improve the investing environment, attract high-tech foreign industries, and reduce the costs of digital startups and transformation of local SMEs.

Digital infrastructure best practices also should shape the incubation competences in emerging digital industries, enhance science and technology innovation capabilities in many cities, and accelerate the modernization process throughout Indonesia.

APJATEL believes that the best practices represented by Surakarta City for digital infrastructure in 2023 will be in harmony with the modernization of other cities, form a consensus in Indonesia Giga City digital infrastructure development and accelerate the digital transformation process throughout Indonesia. Promote digital smart application innovation to thousands of industries in Indonesia, It will also provide smart digital application innovation in thousands of industries in Indonesia and take bold actions towards the era of Golden Indonesia 2045.

10GPON	:	10 Gbps Passive Optical Network
ADS	:	Asymmetric Digital Subscriber Line
AR	:	Augmented Reality
DQ-ODN	:	Digital Quick ODN
eFBB	:	Enhanced Fixed Broadband
EPON	:	Ethernet Passive Optical Network
F5G	:	Fifth Generation Fixed Network
F5G A	:	Fifth Generation Fixed Network Advanced
F6G	:	Sixth Generation Fixed Network
FFC	:	Full Fibre Connection
FTTB	:	Fiber to The Building
FTTH	:	Fiber to The Home
FTTP	:	Fiber to The Premises
FTTR	:	Fiber to The Room
FTTR-2B	:	Fiber to The Room to Building
FTTR-2H	:	Fiber to The Room to Home
FTTS	:	Fiber to The Site
GAO	:	Green Agile Optical network
GPON	:	Gigabit-capable Passive Optical Networks
GRE	:	Guaranteed Reliable Experience
IoE	:	Internet of Everything
IoT	:	Internet of Things
ISDN	:	Integrated Services Digital Network
MR	:	Mixed Reality
ODN	:	Optical Distribution Network
OLT	:	Optical Line Termination
OSV	:	Optical Perception and Visualization
OTN	:	Optical Transport Network
PDH	:	Plesiochronous Digital Hierarchy
PON	:	Passive Optical Network
PSTN	:	Public Switched Telephone Network
RFID	:	Radio Frequency Identification
ROW	:	Right of Way
RRL	:	Real-time Resilient Link
SDH	:	Synchronous Digital Hierarchy
VDSL	:	Very-high-bit-rate Digital Subscriber Loop
VR	:	Virtual Reality
WDM	:	Wavelength Division Multiplexing
WSN	:	Wireless Sensor Networks
XGSPON	:	10 Gigabit Symmetrical PON
XR	:	Extended Reality

