

Giga Thailand

Infrastructure White Paper



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Executive Summary

Broadband infrastructure development is critical to the economy and society current and future development. This report, “Giga Thailand Infrastructure Whitepaper” aims to assist in the development of fixed broadband networks with the goal of enhancing fixed broadband to gigabit speeds, there by enabling the use of future applications and technologies that require efficient utilization of high bandwidth. By conducting research on current and future global fixed broadband technology trends, as well as the current development of fixed broadband networks in Thailand, policy, regulatory, and technological recommendations supporting the development of fiber optic networks are provided. These recommendations are based on international best practices and serve as appropriate benchmarks for Thailand’s goal of becoming a fixed broadband developed nation by 2022–2027. This includes mitigating the digital divide, particularly in rural areas, and establishing the foundation for a sustainable economy and society.

1

The Critical Role of Internet Broadband Speed in Global Economic Growth



The digital economy will increasingly contribute to global economic growth, and digitization will benefit every country's GDP. In 2016, the digital economy worldwide was 15.5% of global GDP. By 2025, the digital economy is predicted to be 24.3% of global GDP¹. According to a study on the effect of digitization on GDP in OECD and non-OECD countries, a 10% increase in digitization results in a 1.35% increase in OECD countries' GDP and a 1.04% increase in non-OECD countries' GDP².

Development of internet broadband speed is critical for a digital economy and will drive GDP growth. As it enables the adoption of innovative technologies for the purpose of increasing productivity and expediting the development of new products, services, and business models. According to a study about the relationship between broadband speed and GDP growth in European Union (EU) member states, a 1% increase in countries with speeds less than 100 megabits per second (Mbps) results in a 0.015% increase in GDP, whereas a 1% increase in countries with ultra-fast broadband speeds greater than 100 Mbps results in an incremental increase of 0.004-0.005% in GDP³.

¹Digital spillover report, Oxford Economics and Huawei, 2017

²How broadband, digitization and ICT regulation impact the global economy report, ITU, 2020

³Oxford Economics and Huawei, loc.cit.

2

The Economic and Importance of Broadband Internet Infrastructures



Gigabit fiber connectivity is significant for long-term development, even to those who are extensively and comprehensively developed. Due to the benefits of gigabit fiber, it is reasonable that fiber will be the major foundation to innovative technologies and applications such as smart cities, augmented and virtual reality (AR/VR), cloud computing, and tele-activities, all of which will contribute to improving people's quality of life, creativity and innovation, and economic growth.

The fixed broadband infrastructure plays a critical role in enabling the deployment of future applications and technologies that require high bandwidth and low latency. A high-speed connection via gigabit fiber cables is critical for optimal usability and the enhancement of user experiences. The following are some examples of applications: 1) Applications such as gaming and education that utilize AR/VR require a minimum of 60–180 Mbps of bandwidth and a maximum latency of less than 10 ms for weak interaction and less than 20 ms for strong interaction. 2) Video applications, such as high-definition video playback and video conferencing, require a minimum of 30 Mbps of bandwidth and a maximum latency of less than 20 ms. 3) Cloud computing activities such as cloud gaming and cloud storage require a minimum of 60–180 Mbps of bandwidth and a maximum latency of less than 20 ms. 4) Tele-activities such as telemedicine require a minimum of 60–180 Mbps of bandwidth and a maximum latency of less than 20 ms. Fixed broadband internet services are frequently used to connect multiple users and devices simultaneously, resulting in a significant increase in bandwidth demand.

3 Growth and Trends in The Global Fixed Internet Broadband Market



Nowadays, there are 1,195 million of fixed broadband subscribers worldwide, representing a 58% household penetration rate. By 2025, the global fixed broadband subscriber base is expected to reach 1,334 million, or a 62% household penetration rate⁴.

The present study shows, fiber optic technology is the most widely used technology for fixed broadband, and it is expected to become a significant technology in the future. Fiber optic technology is currently used by 57% of fixed broadband users. In future forecast, it is predicted to reach 63% of all users by 2025, while cable modem technology will gradually decline in popularity. The xDSL technology will experience a significant decline at an 8.7%⁵ compound annual growth rate as it will be phased out in favor of fiber optic technology

4 Establish Targets for The Development of Thailand's Fixed Broadband Network and Conducting a Gap Analysis

Under the national policies, Thailand Digital Economy and Society Development Plan from MDES, MDES Action Plan (2018–2022) and ONDE Action Plan (2022–2027) have **five key targets related to the development of fixed broadband networks as follows:**

⁴Broadband technology forecast, OMDIA, 2016–2020

⁵Loc. cit.

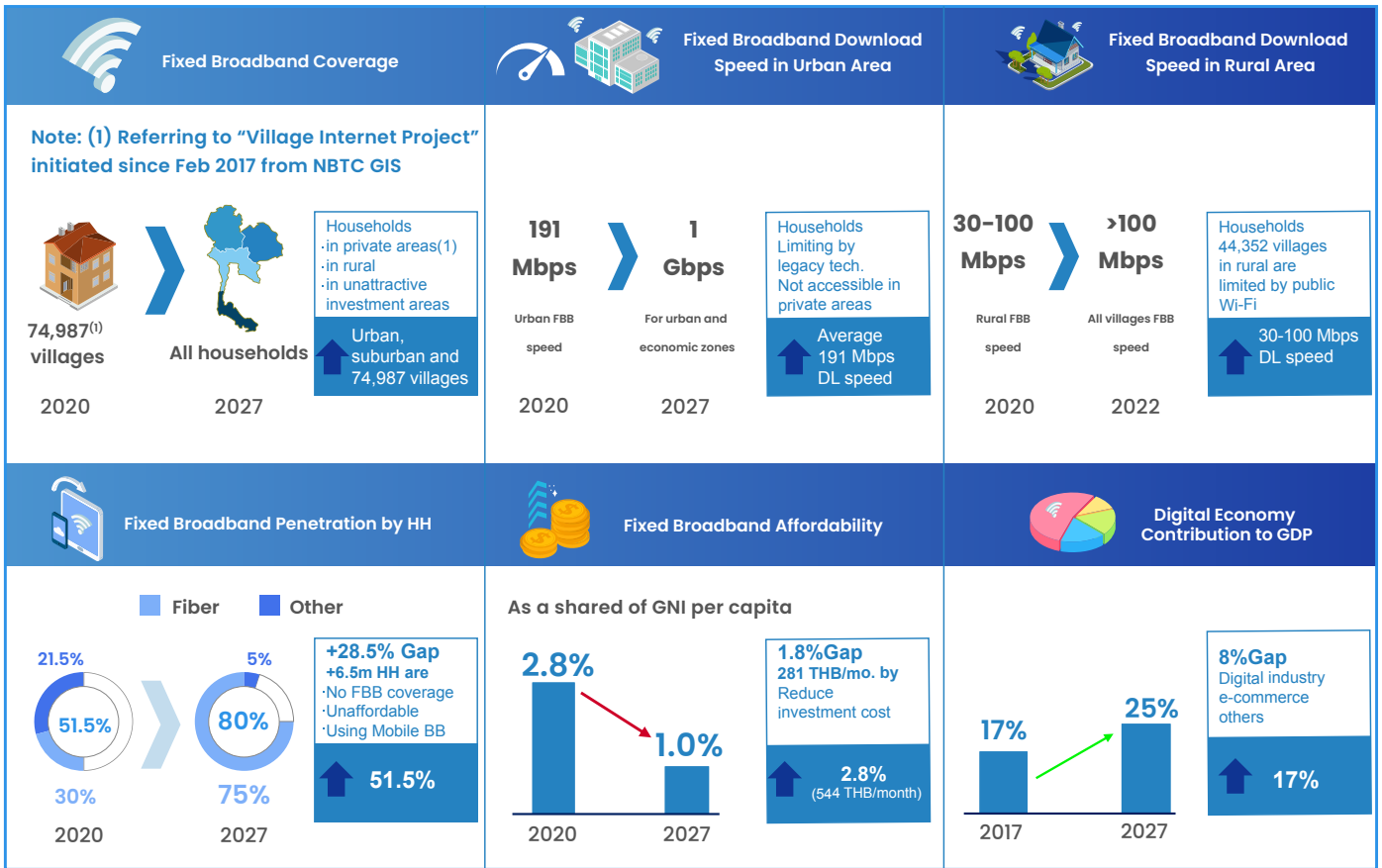


Figure 1: Target of Fixed Broadband Development in Thailand

1st Target: By 2022, the country’s fixed broadband network is expected to be expanded to all villages, and by 2027, all Thai households are expected to have access to fixed broadband. Presently, residents, businesses, and government sectors are able to connect to the internet via fixed broadband networks in all cities and 74,987⁶ villages; however, fixed broadband coverage must be expanded to cover all households, particularly those in rural areas, unattractive investment areas, and private areas (networks in private areas such as residential buildings, office buildings, housing estates, and industrial parks) in order to achieve the goal of providing fixed broadband to all households.

⁶Upgrading Telecommunication Infrastructure Project to Drive the National Economy, GIS data NBTC, 2017

2nd Target: By 2022, it is purposed that every village will have access to fixed broadband speeds greater than 100 Mbps, and by 2027, fixed broadband speeds of at least 1 Gbps will be available in the municipality, economic zone, public utility, and learning center. The average download speed of fixed broadband connections in urban areas is currently 191⁷ Mbps. However, some urban households continue to use copper and coaxial cables. To meet the speed requirement, they should be replaced with fiber optic networks. Additionally, fixed broadband download speeds in 44,352 rural villages covering remote (Zone C) and border (Zone C+) areas are currently set at 30⁸ Mbps. Additionally, 10,000 villages connected to the internet via the “Village Broadband Internet Project” can do so at download speeds of up to 100⁹ Mbps. To achieve the target, the fiber optic network’s speed in Zone C and Zone C+ will be increased to achieve the 100 Mbps target by 2022.

⁷Speedtest, Ookla, 2020

⁸Loc. cit.

⁹Loc. cit.



3rd Target: By 2022, the target is to increase household fixed broadband penetration to more than 70% of the total, and to more than 80% by 2027. It also aims to increase fiber to the home (FTTH) penetration to 50% of households by 2022, and to 75% by 2027. At the moment, fixed broadband penetration is 51.5%¹⁰ among households and FTTH penetration is 30%¹¹ among households. By 2027, an additional 28.5%, or approximately 6.5 million households, will be connected to meet the fixed broadband penetration target. The additional households mentioned above may include those living in areas without fixed broadband internet coverage, low-income households, and households that rely entirely on mobile internet. Moreover, FTTH penetration is expected to increase by 45%, or around 10 million households by 2027, as FTTH technology is the primary technology for fixed broadband development in Thailand. It is expected to grow rapidly in the future and eventually replace other wired technologies, which tend to decrease in usage.

¹⁰Thai Telecom Industry Database, NBTC, 2020

¹¹Loc. cit.



4th Target: By 2022, the goal is to reduce fixed broadband service prices to 2.5% of GNI per capita, and to less than one percent of GNI per capita by 2027.

Thailand's fixed broadband prices currently amount to 2.8%¹² of gross national income per capita, or 544¹³ THB per month. To achieve the goal of 1% of GNI per capita by 2027, fixed broadband service prices must be reduced by 1.8% of GNI per capita or approximately 281 THB per month. As a result, the target monthly fee for fixed broadband is around 263 THB.

5th Target: By 2027, the goal is to expand the Thai digital economy contribution level at 25% of the Thai GDP.

In 2017, Thailand's digital economy contribution level was 17%¹⁴ of the Thai GDP. To accomplish the 2027 target, an additional 8% of investment value from digital and e-commerce sectors will be necessary. On a global scale, the definition and methodology for valuing digital economy activities are currently under research and development.

¹²Calculation from GNI per Capita, World Bank, 2020

¹³Calculation from ARPU and market share of each operator in fixed broadband, NBTC, 2020

¹⁴Digital Ecosystem Report, BOI, 2020



5 The Guidelines of Policy and Governance Implementation under Giga Fiber Development Goals

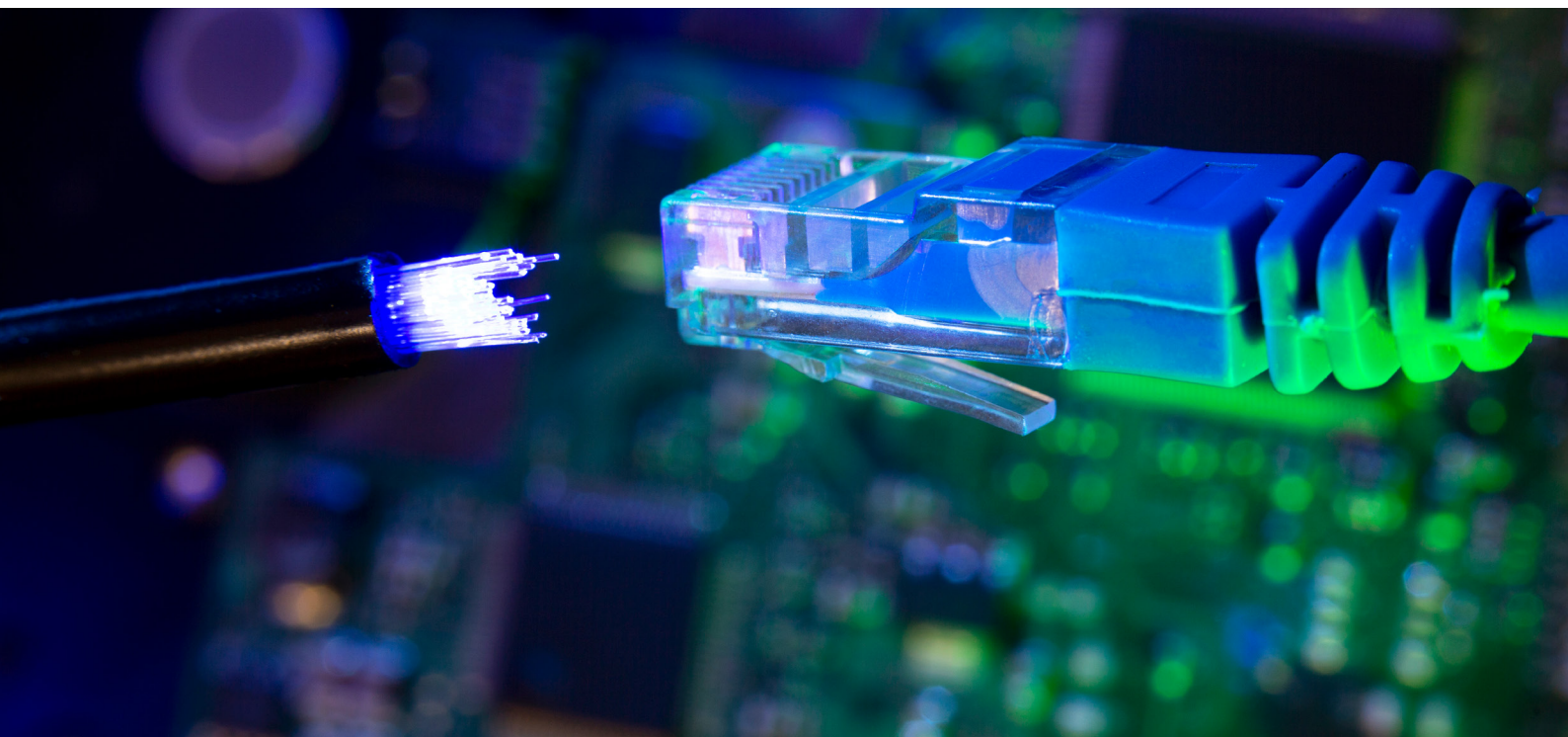
The transparent and fair infrastructures sharing must be promoted and regulated to accelerate the network deployment. Particularly, in the rural areas, the coverage expansion to household through FTTH technology of existing fiber optic network shall be prioritized. For network deployment, the infrastructure sharing can reduce redundancy costs and installation time. The open accessibility and price should be regulated and applied to cover electrical poles, underground ducts, fiber optic cables and networks (last-mile connectivity, and fiber pre-deployment in private areas such as residential buildings, office buildings, housing, and industrial estates). For rural area, the existing fiber optic network established as part of the “Upgrading Telecommunication Infrastructure Project to Drive the National Economy” should be expanded to include individual households and other critical locations via FTTH technology.

Fiber optic networks shall be commonly deployed in municipal areas, replacing copper and cable networks to enable gigabit-speed connectivity. To achieve rural area speed targets, the capacity of the existing fiber optic network should be increased to at least 100 Mbps. The low average broadband speeds in municipal areas are a result of copper and cable technology’s inability to achieve the high speeds. As a result, legacy technology, particularly in private areas, should be phased out in favor of fiber optic technology in order to support the internet connection at 1 Gbps. Fiber pre-deployment in private areas shall be made available via the map-based infrastructure sharing support system to other service providers (Infrastructure Atlas System). Rural areas can achieve speeds of greater than 100 Mbps by retrofitting the network configuration or upgrading the GPON technology in accordance with the ITU’s roadmap. Additionally, a broadband monitoring system should be implemented to track the network’s expansion and quality.

Apart from accelerating municipal fiber optic network expansion, the country's overall fixed broadband penetration rate should be increased by increasing the number of fixed broadband subscribers, particularly in non-municipal areas. For municipal areas, the number of connections will be able to grow rapidly as operators may accelerate network expansion for coverage through infrastructure sharing, particularly fiber pre-deployment in private areas. Internet utilization should be increased in rural areas by encouraging residents to use internet-based applications that enhance the quality of life. This will not only increase the number of fixed broadband users, but also has the potential to alleviate the digital divide.

Cost reduction policy such as infrastructure sharing may effectively support operators in lowering their internet service charges. Meanwhile, low-income subscribers, especially those in rural areas may need a subsidy supported by USO fund to get access to internet at a lower cost.

The Investment and expenditure in the digital economy as well as productivity in the digital industry shall be increased to achieve the target level of digital economic growth and contribution to GDP.



GPON, XG-PON, IPv6, Wi-Fi 6, DWDM, digitalized Quick ODN technology, and regulation compliance tools under the map-based system are the necessities and technologies that can support the adoption of gigabit-speed broadband.

The following details are included:

1) GPON Technology: While fixed broadband providers are currently using GPON technology to provide gigabit broadband, operators may need to upgrade to XG-PON technology in accordance with the ITU's roadmap increase speed and also to replace legacy copper and coaxial cable technology.



2) IPv6: IPv6 connectivity is required to expand the ability to handle exponentially growing device connections that exceed the IPv4-based IP address limit. Due to the fact that IPv6 connections can support a significantly greater number of devices than IPv4 connections and other benefits, service providers should implement an IPv6 transition strategy.



3) Wi-Fi 6: It will be capable of transmitting data at a higher rate than Wi-Fi 5, connect more devices and significantly lower the latency, thereby enabling gigabit connections to end devices.

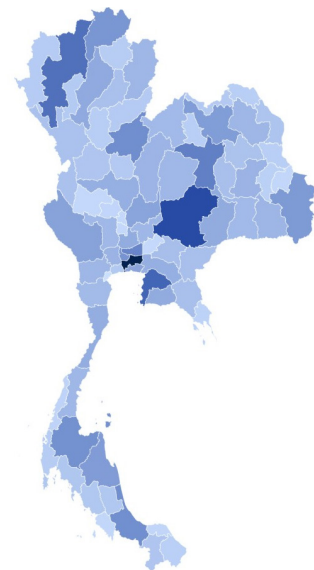


4) DWDM technology: It is a technology for transmitting signals of varying wavelengths across fiber optic cable. The technology will increase the bandwidth and data transmitted in order to increase the speed of data transmission. It can enable data transfer rates of up to 20 Tbps per system, or more, significantly increasing the capacity of the core network.



5) Digitalized Quick ODN: DQ ODN can reduce the time required to connect fiber optic cables to end-users in last-mile connections. Implementing pre-connectorized ODN (Optical Distribution Network) devices could eliminate the requirement for on-site splicing. Additionally, a management system is also included, which makes it easier to record complex ODN data.

6) Regulation compliance tools under the map-based system: Policy and regulation innovation is critical to ease the massive deployment of fiber optic cables for example, the first is the Infrastructure Atlas System, which facilitates infrastructure sharing. Secondly, the Broadband Monitoring System, which monitors fiber optic network expansion and the quality of broadband internet service nationwide.



6 Operation Plans

The operation plans for developing fixed broadband networks are divided into four major categories: 1) Increasing the regulation of infrastructure sharing 2) Advancing regulatory policies as well as establishing standards for fiber pre-deployment in private areas 3) Mitigating digital divide 4) Developing the regulation supporting systems and a mechanism for promoting the use of related technology.



Figure 2: Operation Plans to Drive The Development of Fixed Broadband Networks in Thailand

Infrastructure sharing regulations are composed of three components: 1) establishing an information center to consolidate the fundamental utility projects and plans 2) considering to improve the governance regulations regarding to the reference pricing regulation on underground duct rental rates. 3) considering to strengthen the regulation of open access to fiber optic networks for other service providers in private areas. The following are the details of regulations in each aspect:

- ◆ The NBTC should establish an information center for collecting and sharing data on infrastructures as well as fundamental utility projects and plans. This information center will be used to facilitate coordination between infrastructure and utility agencies, as well as telecommunications operators, in planning for the expansion of infrastructure utilities and telecommunications infrastructures.

- ◆ The NBTC considers ways to improve the regulation of underground duct rental rates by utilizing reference rates, researching appropriate standard calculations such as LRIC+, and calculating the reference rate. To assist operators in migrating communication cables financially through funding or tax deductions, the NBTC will collaborate with the ONDE and other funds, including the Digital Economy and Society Development Funds (DES Funds), the Broadcasting and Telecommunications Research and Development Fund for Public Interest (BTFR), and the Environmental Fund.

- ◆ The NBTC considers to improve the regulations of open-access fiber optic networks in private areas on price regulation by regulating the method of rental rate calculation and intensely reviewing the operator's RAO in terms of service level agreements (SLAs) and penalties to ensure fairness and practicability.



Advocating for private area fiber optic network installation policies and standards includes the following: 1) advancing the fiber pre-deployment policy in private areas 2) establishing standards for the design, installation, and acceptance of fiber pre-deployment in private areas, as well as establishing a reference budget. The following are the details of governance in each area:

- ◆ The NBTC, in collaboration with ONDE, promotes and launches policies governing fiber optic cable networks. Particularly for new building constructions, as building owners or real estate developers are required to establish the fiber network while obtaining approval for their new building constructions. To advance the policies, NBTC and ONDE will collaborate with related government organization for example the Building Control Bureau, the Department of Public Works, and town & Country Planning to develop ministerial regulations and submit them to the Building Control Committee for consideration and approval in accordance with the Building Control Act B.E. 2522. Under Section 8 Public Work Department under Bangkok Metropolitan Administration and local government organization in big cities to develop the local ordinance. Additionally, NBTC and ONDE will promote collaboration between operators and real estate developers in order to establish a financial mechanism or tax deduction system to assist with the installation of fiber optic cable networking in existing buildings. The regulation on open access in private areas will apply to existing buildings that have already installed fiber optic networks.

- ◆ The NBTC, in collaboration with related organizations for example the Department of Public Works and the town & Country Planning and Engineering Institute of Thailand, conducts research and establishes standards for the design, installation and acceptance of fiber optic cable network projects in private areas, as well as calculating the fiber installation cost for industry's reference.

The mitigating digital divide is categorized as 1) expanding fixed broadband access network coverage to government agencies and rural households via FTTH technology 2) Encourage the use of fixed broadband. The details of activities are as follows:

- ◆ The Bureau of General Telecommunications and Social Services should expand the coverage of existing fiber optic network in villages to connect important government agencies, the individual households by using FTTH technology to meet the needs of both ease of access and speed.

- ◆ The Bureau of General Telecommunications and Social Services should promote and expand the use of fixed broadband by 1) collaboratively working with relevant government agencies to create contents and facilitates the use of useful applications such as electronic education systems, remote medical service systems, electronic administrative office and electronic commerce systems; 2) organizing information and communication technology (ICT) training in collaboration with local administrative organizations; and 3) considering providing financial support to subsidize installation costs, monthly service fees, and equipment costs as needed.



The establishment of a system to support and encourage the adoption of related technologies entails 1) the acquisition of a map-based infrastructure sharing support system; and 2) the acquisition of a map-based broadband monitoring system. The following are the details in each system:

- ◆ The NBTC shall consider acquiring a map-based system to facilitate infrastructure sharing. The initial data can import from NBTC's existing database.

- ◆ The NBTC shall consider acquiring a broadband monitoring system for tracking the progresses of fiber optic network expansion and the quality of broadband across the country.

The NBTC should promote the adoption of IPv6 technology in order to increase the capacity of IP addresses and encourage operators to educate consumers about the benefits of Wi-Fi 6. The NBTC should stimulate the use of capable technology of enabling gigabit broadband, including IPv6 and Wi-Fi 6.

For IPv6, NBTC should encourage information technology-related associations to host seminars to share knowledge and methods for transitioning from IPv4 to IPv6.

For Wi-Fi6, telecommunications operators should raise awareness of the benefits of Wi-Fi 6 in order to optimize the use of fixed broadband capable of gigabit speeds via media such as infographics.





Introduction

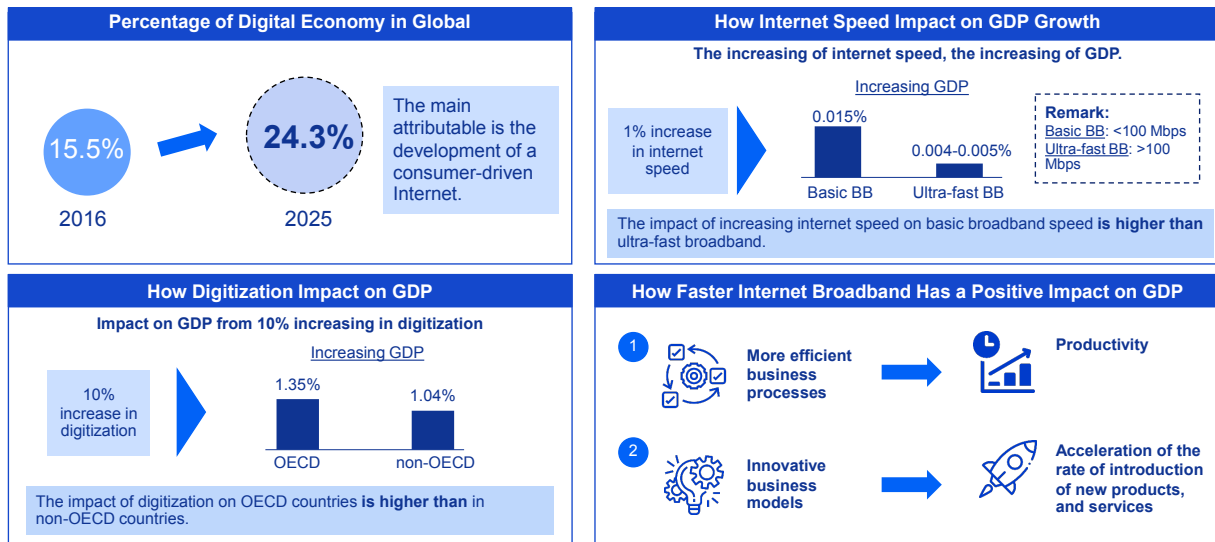
Presently, the digital economy is growing, and it has become the primary driver of the global economy. In 2016, the value of the digital economy was estimated to be at 15.5% of the global economy. and the value of the digital economy is anticipated to increase and is expected to reach 24.3% of the global economy by 2025¹⁵. As the development of digital infrastructure is necessary for the economic and social development of a country to be in a sustainable way, investing in digital technology will increase the country's productivity and result in an increase in Gross Domestic Product (GDP). According to a study on how digitization affects GDP in OECD and non-OECD countries, a 10% increase in digitization results in a 1.35% increase in OECD countries' GDP and a 1.04%¹⁶ increase in non-OECD countries' GDP. Additionally, the long-term return on digital technology investments is greater than the return on non-digital investments, which accounted for 6.7 times¹⁷ the return on digital technology investments. Blockchain, data analytics, artificial intelligence, 3D printing, the internet of things, automation and robotics, and cloud computing¹⁸ are all recent trends in digital technology.

¹⁵Digital spillover report, Oxford Economics and Huawei, 2018

¹⁶How broadband, digitization and ICT regulation impact the global economy report, ITU, 2020

¹⁷Oxford Economics and Huawei, loc.cit.

¹⁸Digital economy report, UN, 2019



Source: Oxford Economics and Huawei (2017), ITU (2020)

Figure 1-1: The Importance of Developing Digital Infrastructure for GDP and The Economy.

The growth of the digital economy increases demand for internet broadband and reveals a greater new internet broadband requirement for increased bandwidth, speed, and decreased latency. Adoption of new digital technologies necessitates the development of internet broadband infrastructure capable of supporting gigabit fiber connectivity for business enterprises for instance, businesses can improve their efficiency by implementing new digital innovations in real time on their business and production processes. Additionally, it enables consumers to access high-bandwidth applications such as augmented reality/virtual reality, 4k and 8k high-definition video, cloud gaming, cloud storage, cloud computing, remote learning, and telemedicine. Additionally, gigabit fiber speeds the development of new products, services, and business models.

According to a study on the relationship between broadband speed and GDP growth in European Union (EU) member states, a 1% increase in countries with less than 100 megabits per second (Mbps) results in a 0.015 percent increase in GDP, while a 1% increase in countries with ultra-fast broadband speeds greater than 100 Mbps results in an incremental increase of 0.004-0.005 percent in GDP¹⁹.

¹⁹Oxford Economics and Huawei, loc.cit.

As a result, it demonstrates unequivocally that increasing the speed of internet broadband has a beneficial effects on the digital economy and GDP. Gigabit fiber is critical for sustainable development, particularly when developed extensively and comprehensively, as it enables the development of new innovations and digital ecosystems such as smart homes, smart manufacturing, and smart cities.

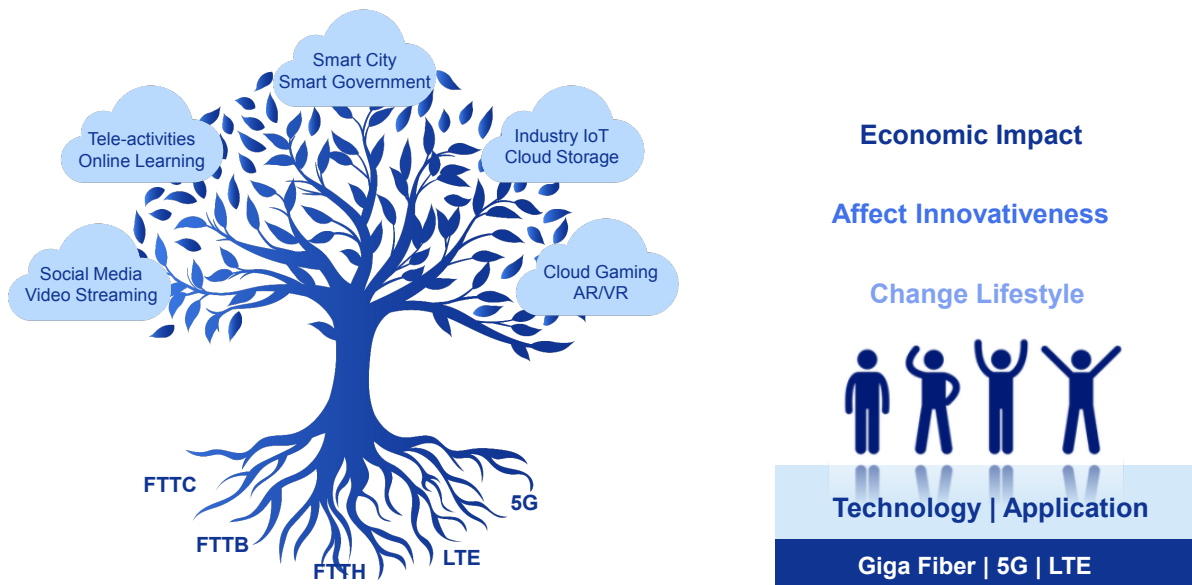


Figure 1-2: The Importance of Developing Giga Broadband via Fiber Optic



2 The Globally Development Trends of Fixed Broadband

2.1 Global Market Trends and Direction of Fixed Broadband Internationally

Fixed broadband is an internet service with a minimum download speed of 256 Kbps that can be delivered via wireline or wireless technologies such as copper, coaxial, or fiber optic cables, as well as fixed wireless broadband. By 2020, there will be 1,195 million fixed broadband subscribers worldwide, equating to a 58% household penetration rate. By 2025, fixed broadband subscribers are expected to reach 1,334 million worldwide, or 62% of households²⁰.

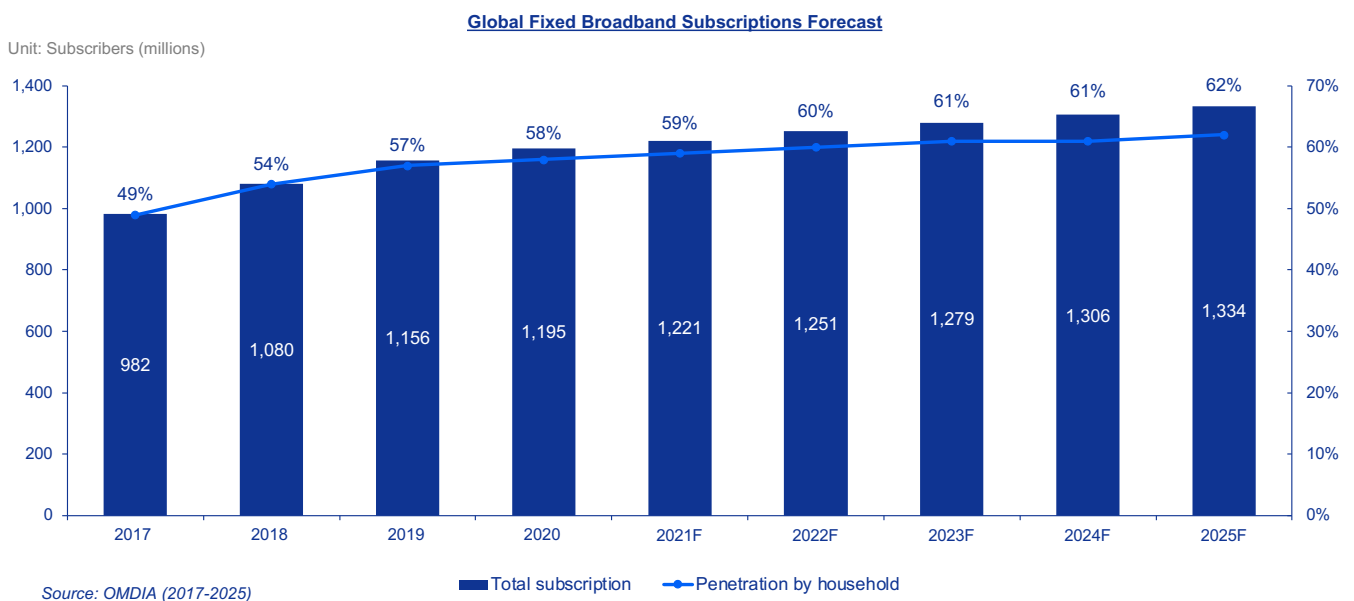


Figure 2-1: The Number of Fixed Broadband Subscription Globally

²⁰Broadband technology forecast, OMDIA, 2016-2020

for fixed broadband, the most widely used technology is FTTH/B which is expected to be a significant technology in the future as well. By 2020, 57% of fixed broadband users will be using FTTH/B technology, up from 57% in 2017. Thus, it is expected to reach 63% of fixed broadband users by 2025, growing at a 3.73% compound annual growth rate, while cable modem technology continues to decline at a 1.31% compound annual growth rate. As xDSL technology is phased out in favor of fiber optic connections, its market share will undoubtedly decline at an 8.7%²¹ eight-years CAGR.

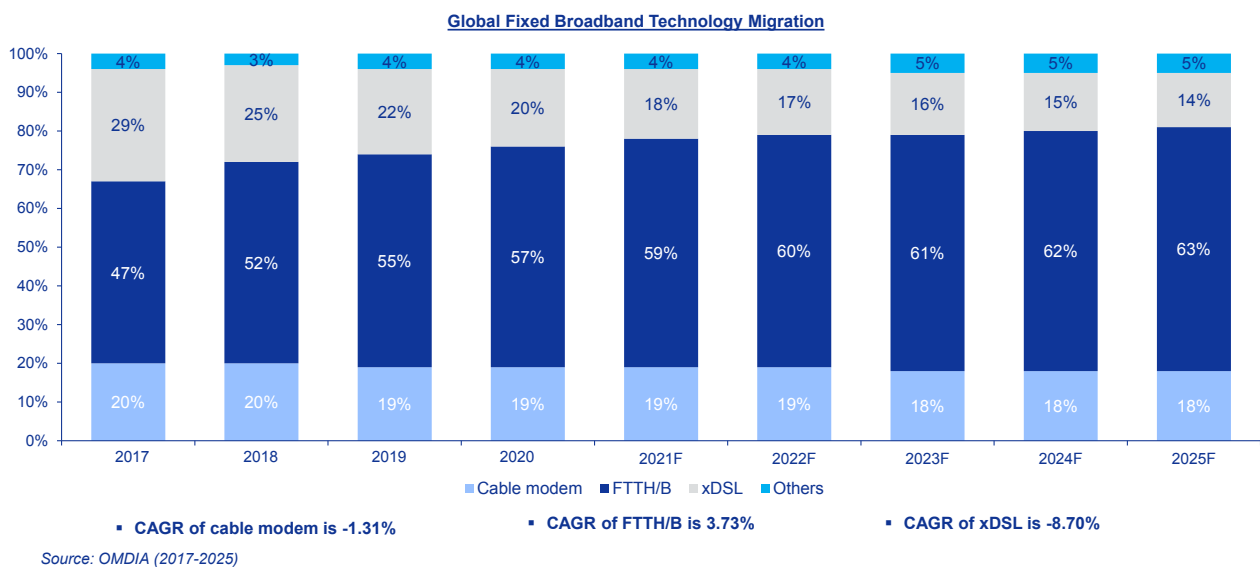


Figure 2-2: The Proportion of Used Technology in A Fixed Broadband

²¹ World fixed subscription forecast, OMDIA, 2020-2025



2.2 The Growth of Fiber Optic Broadband in International Countries

Fiber optic broadband is a critical technology for fixed broadband now, and it is likely to continue to be a significant technology in the future. According to a study on the growth of fiber optic broadband connectivity between developed and developing countries, both have seen a noticeable increase in fiber optic network coverage. Japan, Sweden, Spain, New Zealand, and France were designated as developed countries, while Singapore, the United Arab Emirates, China, South Korea, and Vietnam were designated as developing countries²² due to their leadership in fiber optic broadband.

The study states, household penetration of fiber optic broadband has been higher in developing countries in the last five years than in developed countries since 2017. Additionally, it is anticipated to continue increasing in the future. Developed countries continue to rely on legacy technology, such as copper and coaxial cables, to connect to the internet. Nonetheless, developed countries have been transitioning from legacy technology to fiber optics over the last five years, resulting in the continuous growth of fiber optic networks both now and in the future.

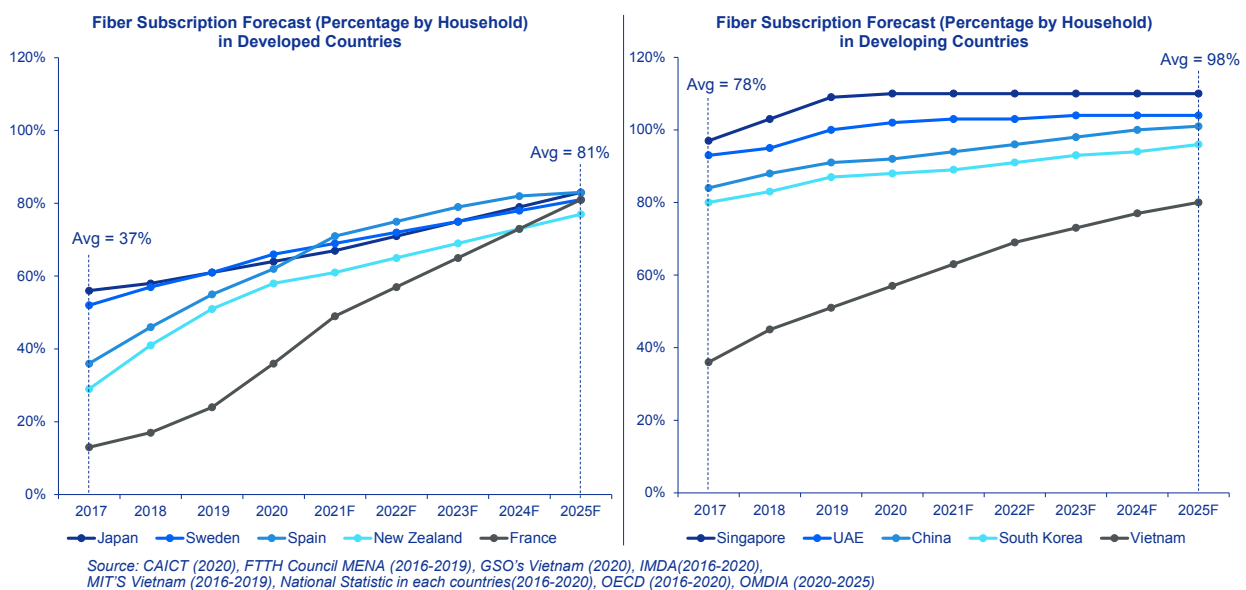









Figure 2-3: The Growth of Fiber Penetration by Household in Developed and Developing Countries

²²World Economic Situation Prospects, UN, 2020

2.3 Targets of Fixed Broadband Development in International Countries.

Due to the development advantages of fixed broadband, both developed and developing countries are concentrating their efforts on the development of digital infrastructures. The following are some examples of European Union countries that have established targets and plans for fixed broadband expansion:

	The National Broadband Plans	Broadband Targets
	Europe Strategy 2020 and The Gigabit Society for 2025	2020: 100% Europeans households access to fast broadband (> 30 Mbps) 2025: 100% European households, rural or urban, should have access to connectivity offering a download speed of at least 100 Mbps
	The France National Program for Very High-Speed Broadband Plan	2022: 100% of home access to the high-speed broadband (> 30 Mbps) and 80% optic fiber 2025: 100% of home access to the optic fiber
	Gigabit Initiative for Germany (2018-2025)	2018: 100% households access to fast broadband (> 50 Mbps) 2019: 100% business parks with fiber connections 2025: Establishes a coverage gigabit-ready infrastructure
	The Sweden Broadband Strategy (2016-2025)	2020: 95% households and companies access to broadband (> 100 Mbps) 2025: 100% households and companies access to high-speed broadband (> 1 Gbps)
	The Ireland National Broadband Plan (2019-2026)	2026: All premises access minimum download speed of 150 Mbps and fiber will cover 96% in Ireland's mass
	The Hungary National Digitization Strategy (2020-2030)	2020: 100% Broadband coverage with average speed of 30 Mbps 2030: 95% households covered by gigabit network
	Digital Spain 2025	2025: 100% population access high-speed broadband (> 100 Mbps)

Source : European Union website

Figure 2-4: Examples of The EU Countries' Fixed Broadband Development Goals

The European Union has developed "The Strategic Plan 2020 and The gigabit Society for 2025," with the goal of covering all households with fixed broadband speeds greater than 30 Mbps by 2020 and greater than 100 Mbps by 2025.

France has developed "The France National Program for Very High-Speed Broadband," with the goal of covering all households with fixed broadband speeds greater than 30 Mbps and expanding the fiber optic network to cover 80% of households by 2022. By 2025, it intends to extend fiber optic to cover 100% of households.

Germany has developed "The Gigabit Initiative Plan" with the goal of covering all households with fixed broadband speeds greater than 50 Mbps by 2018 and








all business parks with fiber optic broadband by 2019. The goal for the future is to develop gigabit broadband infrastructure nationwide within 2025.

Sweden has developed “The Sweden Broadband Strategy”, which aims to provide fixed broadband speeds of at least 100 Mbps to 95% of households by 2020, and to provide broadband internet speeds greater than 1 Gbps to all households by 2025.

Ireland has developed “The National Broadband Plan,” which aims to provide fixed broadband download speeds of at least 150 Mbps to all premises and to expand fiber optic to cover 96% of the country by 2026.

Hungary has developed “The National Digitization Strategy Plan” with the targets of providing fixed broadband speeds at 30 Mbps to cover nationwide by 2020. within 2030, it is expected to expend gigabit network to cover 95% of households.

Spain has developed “The Digital Plan” with the targets of providing fixed broadband speeds higher than 100 Mbps to cover all the population by 2025. In addition, the following are some examples of fixed broadband development targets and plans for Asian countries:

	The National Broadband Plans	Broadband Targets
	China Dual Giga Initiative 2021-2023	2021: Giga cities > 20 cities , Giga fiber covering 200M family , 10G-PON port > 5M ports , Giga subscribers > 10M , 5G new sites 600k sites 2025: Giga cities > 100 cities , Giga fiber covering 400M family , 10G-PON port > 10M ports , Giga subscribers > 30M , 5G new sites most villages
	Malaysia Vision 2030	2021: 500 Mbps covering specific areas in the capital and provincial 2023: 98% population access an average speed of 30 Mbps and 100% gigabit coverage of national industrial parks
	Singapore National Broadband Plan	2012: 50% Fiber coverage of households and businesses 2015: 95% Fiber coverage of households and businesses
	India National Broadband Plan	2022: 100% villages access to broadband internet (50 Mbps) 2024: Increase 3 million routes of optical fiber cable
	Japan National Broadband Plan	2022: Complete national fiber-optic networks 2024: 480,000 households in rural areas and remote islands access fiber optic networks
	Turkey National Strategy Plan (2019-2023)	2023: 100% households access to broadband (> 100 Mbps) and 20% households access to high-speed broadband (> 1 Gbps)
	Kazakhstan National Broadband Plan	2020: 1,250 villages in rural areas connect to the fiber optic 2022: 97% population access to high-speed broadband internet 2023: Roll out 5G in all regional centers of the country

Source : Oxford Business Group, The Japan Times, The Government of Kazakhstan, and The Economic Times

Figure 2-5: Examples of The Asian Countries' Fixed Broadband Development Goals

China has developed “The Dual Giga Initiative Plan” with five targets by 2021 as following: 1) Gigabit cities will expand to 20 cities 2) Gigabit fiber optic network will cover to 200 million households 3) XG-PON ports will be increased more than 5 million ports 4) Gigabit subscribers will increase to 10 million households and 5) The 5G network will be expanded to 600,000 sites covering districts and some rural areas. Furthermore, the country has established the following five targets for 2025: 1) Gigabit cities will expand to 100 cities 2) Gigabit fiber optic network will cover 400 million households 3) XG-PON ports will be increased to 10 million ports 4) Gigabit subscribers will increase to 30 million households and 5) 5G network will cover all villages.

Malaysia has developed “The Economic Development Plan” with the targets of providing fixed broadband speeds at 500 Mbps to cover specific areas in the capital and provincial by 2021. By 2023, fixed broadband speeds at 30 Mbps will cover 98% of the population and gigabit network will cover all national industrial parks.

Singapore has developed “The Intelligent Nation Plan” (iN 2015) with the goal of covering 50% of households and businesses with fiber optic by 2012 and covering 95% of households and businesses with fiber optic by 2015.



India has developed “The National Broadband Plan” with the targets of providing fixed broadband speeds at 50 Mbps to cover 100% of all villages by 2022 and increasing 3 million routes of fiber optic cable by 2024.

Japan has developed “The National Broadband Plan” with the targets of implementing national fiber optic network by 2022 and covering 480,000 households in rural areas and remote islands by 2024.

Turkey has developed “The National Digital Development Plan” with the targets of providing fixed broadband speeds higher than 100 Mbps to cover all of households and higher than 1 Gbps to cover 20% of households by 2023.

Kazakhstan has developed “The National Vision Plan” with the goal of covering 1,250 villages in rural areas with fiber optic networks by 2020. By 2022, it plans to cover 97% of the population with high-speed fixed broadband, and by 2023, it plans to roll out a 5G network in every region of the country.



3 Thailand's Current State of Fixed Broadband Service

3.1 Thailand's Fixed Broadband Market

3.1.1 Fixed Broadband Penetration Rate

Thailand's fixed broadband market has grown rapidly over the last five years. According to the National Broadcasting and Telecommunications Commission (NBTC), fixed broadband penetration by population was 17%²³ in 2020 and fixed broadband penetration by households was 51.5%²⁴, representing a 12% four-year CAGR. The total number of fixed broadband subscribers grew by 14%, from 10.11 million subscribers in 2019 to 11.5²⁵ million subscribers in 2020, resulting in a higher fixed broadband penetration rate. Furthermore, fiber to the home (FTTH) penetration continues to grow, reaching 30%²⁶ of households in 2020, up 28% from the previous year. However, according to topic 2.2, FTTH penetration in Thailand remains low in comparison to both developed and developing countries. As a result, Thailand will need to increase FTTH penetration in the future.



²³Thai Telecom Industry Database, NBTC, 2020

²⁴Loc. cit.

²⁵Loc. cit.

²⁶Loc. cit.

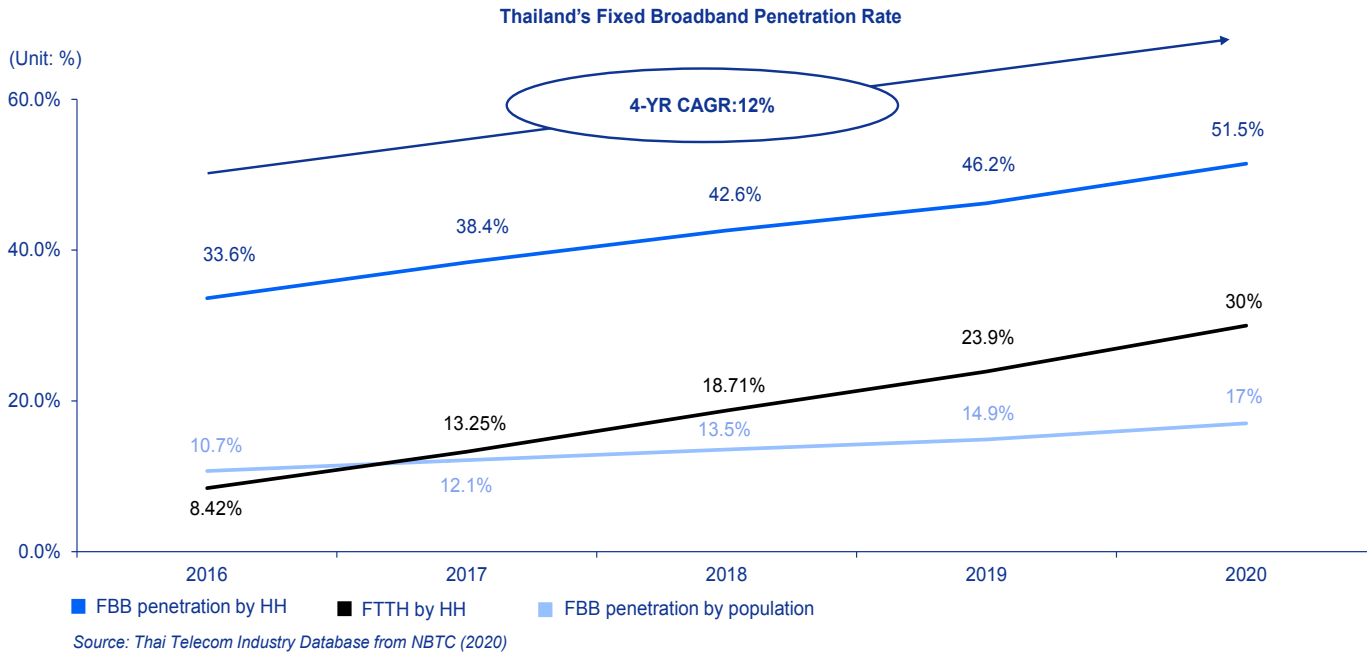


Figure 3-1: Thailand's Fixed Broadband Penetration and FTTH Penetration

3.1.2 Fixed Broadband Subscribers by Technology

According to NBTC data, there were 11.5²⁷ million fixed broadband subscribers in 2020, up 14% or approximately 1.4 million subscribers from 2019, as fiber optic networks expanded coverage in areas where xDSL technology was not available. Additionally, new normal customer behavior and price competition promote increased fixed broadband usage, resulting in an increase in fixed broadband subscribers. Thailand's fixed broadband subscribers diving by types of technology indicate that fiber optic subscribers have grown steadily since 2016 to 6.7 million subscribers in 2020, representing a 39% of four years CAGR. While xDSL subscribers, cable broadband subscribers, and others have decreased by more than 0.58 million since 2016, bringing total xDSL subscribers to less than 4 million in 2020. As a result, fiber optics is expected to grow in popularity in the future. Due to its proclivity to supplant older technologies whose usage is dwindling, it is a significant technology in the growth of the fixed broadband market.

²⁷TTID, NBTC, 2020

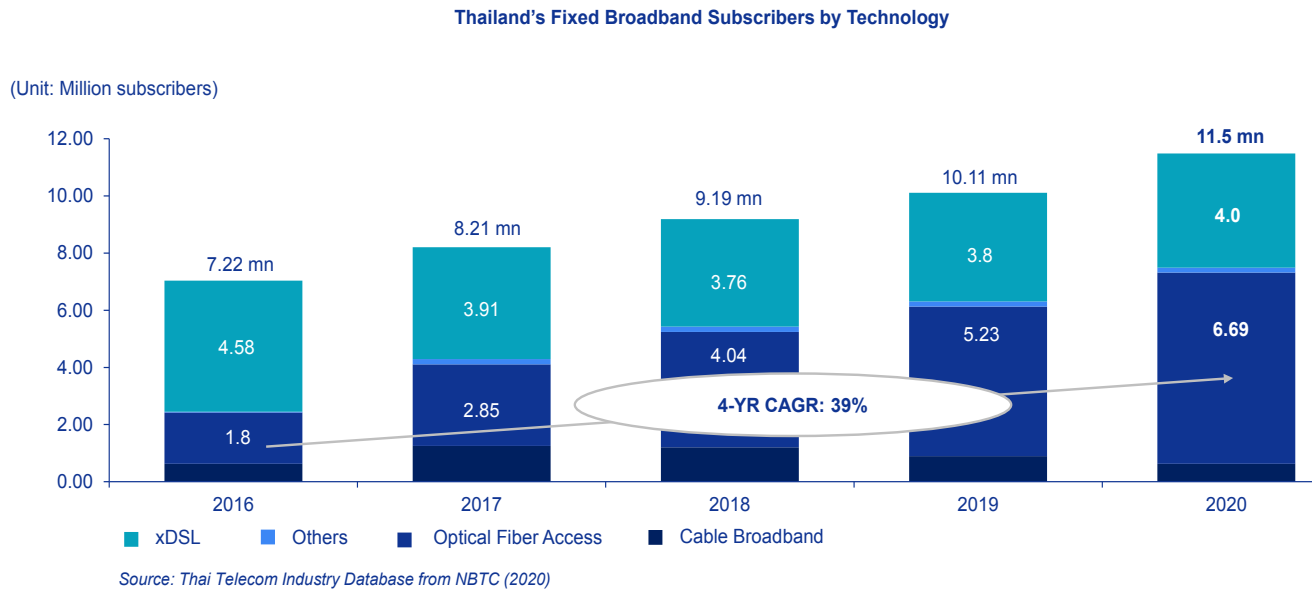


Figure 3-2: Thailand's Fixed Broadband Subscribers by Technology

3.1.3 Fixed Broadband Service Prices of GNI per Capita

In 2020, fixed broadband service prices were 2.83% of GNI per capita based on the average ARPU of each service provider and their market share in the fixed broadband market²⁸. Figure 3-3 indicates that fixed broadband prices decreased by 0.6%, is compared at 3.42% of GNI per capita in 2017 to 2.83% by 2020, since fixed broadband coverage has expanded and price competition has intensified. Therefore, fixed broadband prices have decreased and are expected to decrease in the future continually

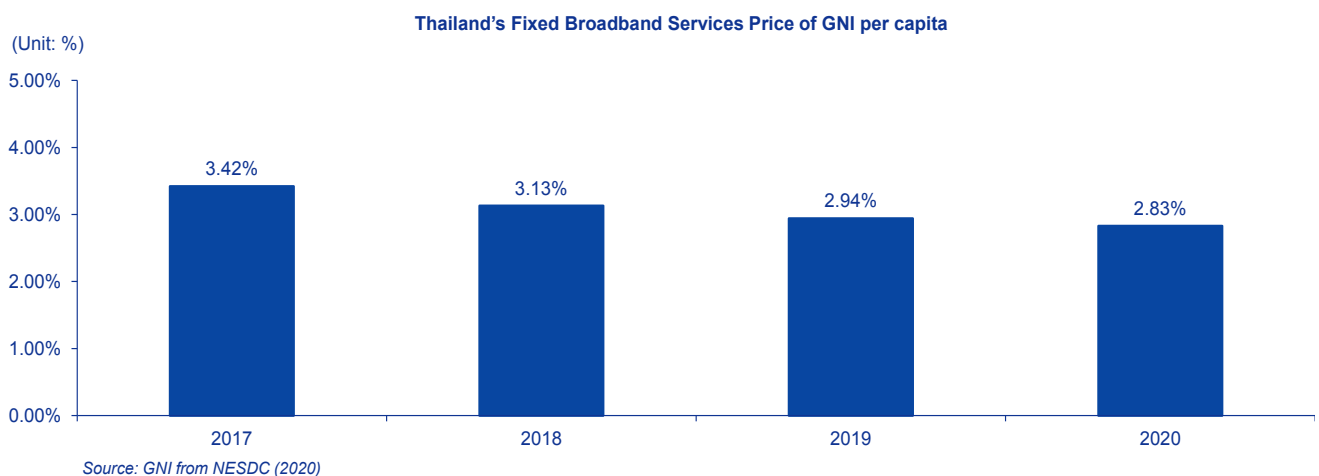


Figure 3-3: Thailand's Fixed Broadband Service Prices of GNI per Capital

²⁸Fixed broadband market share, NBTC, 2020

3.1.4 Digital Economy Contribution to GDP

According to the Board of Investment's (BOI) Digital Report 2019, Thailand's digital economy contributed 17% of GDP in 2017. It is expected to reach 25% by 2027 as a target in Thailand Digital Economy and Society Development Plan (2018 – 2037). However, the concept and meaning of the digital economy are still being researched and developed at the international level in light of current circumstances. Additionally, Thailand is in the process of standardizing its framework for measuring the digital economy.

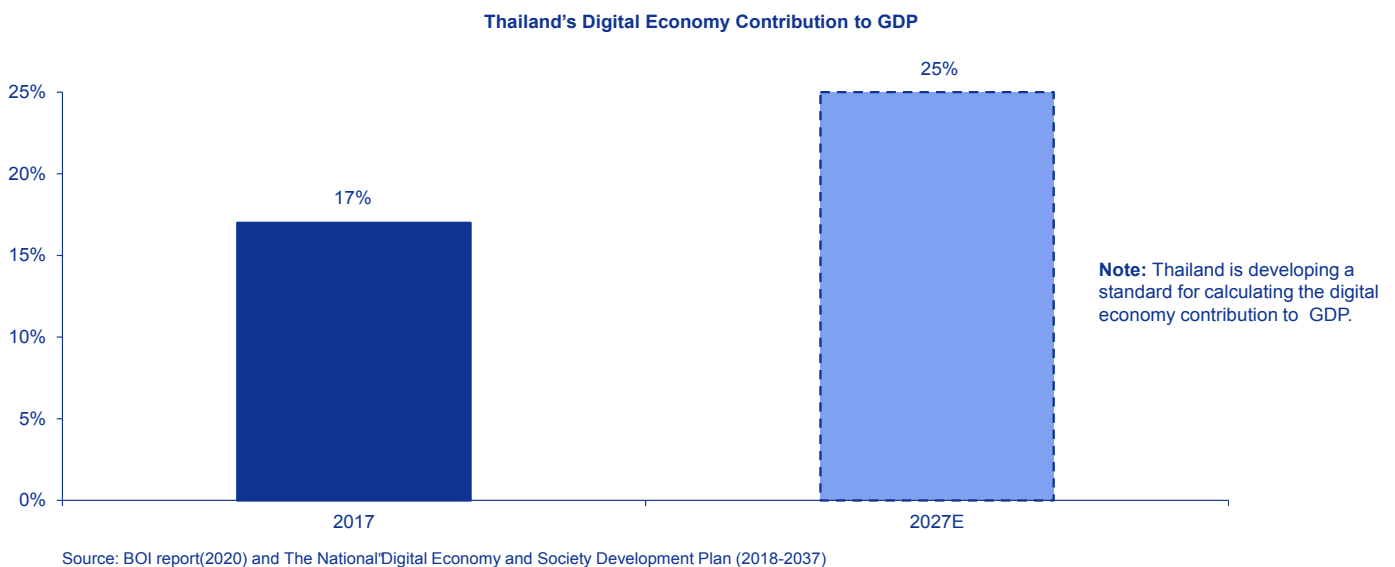


Figure 3-4: Thailand's Digital Economy Contribution to GDP and Target

3.1.5 Fixed Broadband Speed

According to Ookla's Speedtest.net, Thailand's average fixed broadband download and upload speeds were 191.16 and 150.52 Mbps respectively, with an 8-millisecond latency in December 2020. When compared to June in 2020, Thailand's average speed and latency have improved. They are expected to continue to improve in the future.

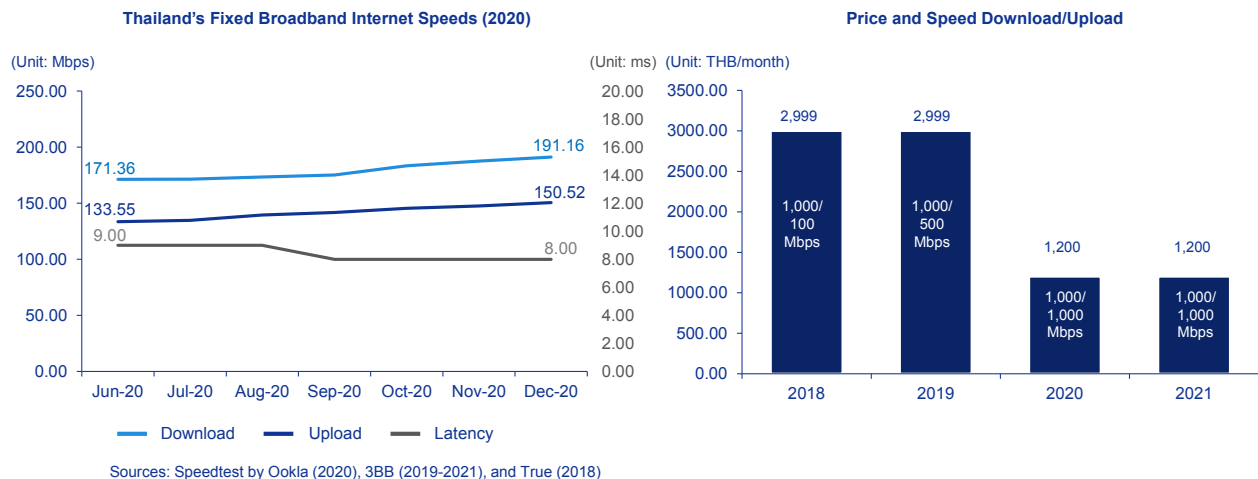


Figure 3-5: Thailand's Fixed Broadband Speeds and Price Plans

Since 2018, Thailand has offered a fixed broadband internet package with download speeds 1 Gbps at a monthly cost of up to 2,999 THB. However, as technology improved and fiber optic network coverage expanded, the number of fiber optic subscribers has increased. As the market for fixed broadband internet confronts in price competition, the price for fixed broadband internet packages decreased to 1,200 THB per month in 2021. In addition, the upload speeds were raised to 1 gigabit per second. Fixed broadband prices are expected to decline in the future.



3.2 Density of Fiber Optic, Copper, and Coaxial Cable

Thailand's fixed broadband service is available via fiber optic, copper, or coaxial cable. During 2012–2020, total cable installation permission for fiber cable, copper cable and coaxial cable are 988,993, 10,039 and 15,113 Kilometers respectively. Bangkok, Nakhon Ratchasima, Chonburi, Chiang Mai, Khon Kaen, Pathum Thani, Phitsanulok, Songkhla, Surat Thani, and Nonthaburi²⁹ are the top 10 provinces in Thailand with the highest density of fiber optic network. Khon Kaen, Chiang Mai, Bangkok, Nakhon Ratchasima, Sakon Nakhon, Roi Et, Nonthaburi, Sukhothai, Chiang Rai, and Lamphun³⁰ are the top 10 provinces with the highest density of copper and coaxial cable. These provinces have a high population density and a high household density per area, indicating a high demand for fixed broadband internet. As a result, fiber optic, copper, and coaxial cable have a high density.

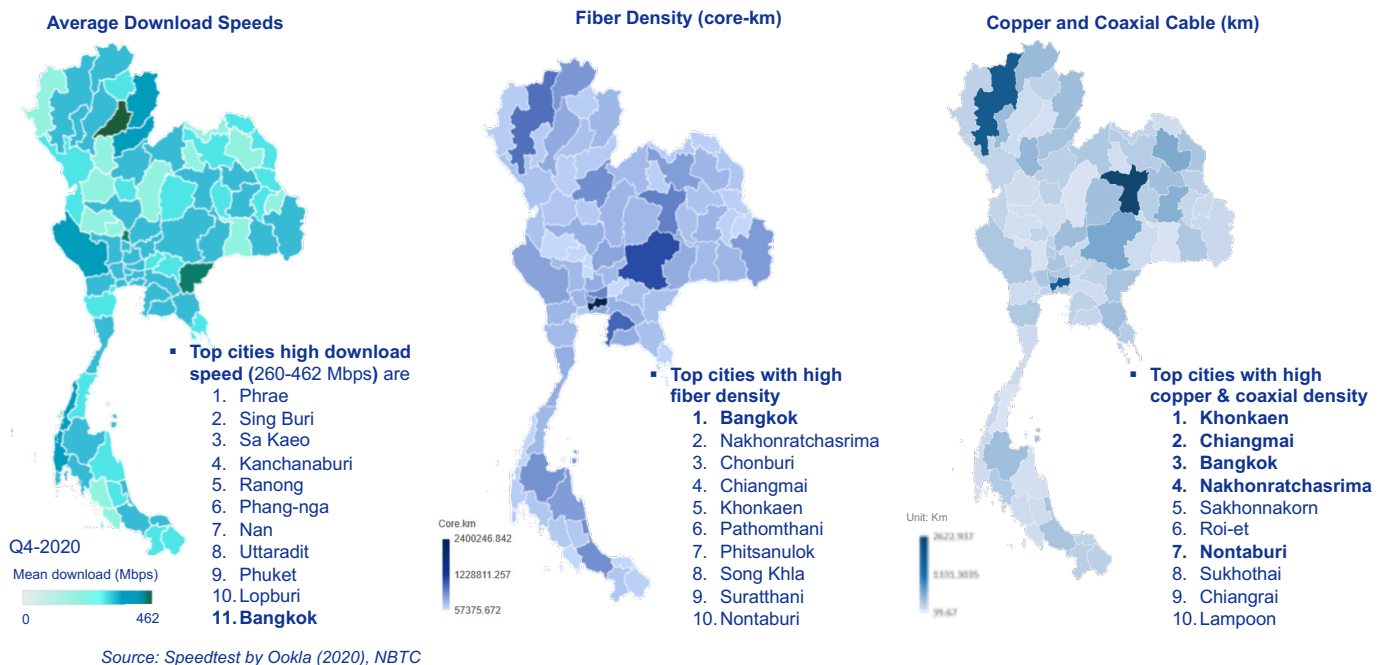


Figure 3-6: Thailand's Density of Fiber Optic, Copper, and Coaxial Cable

²⁹Calculating from the distance of fiber optic multiply with number of installed cores, NBTC, 2020

³⁰Calculating from the distance of copper and coaxial cable multiply with number of installed cores, NBTC, 2020

Each province in Thailand has an average download speed of 180 to 462 Mbps, according to the fixed broadband internet download speed ranking. Phrae, Sing Buri, Sa Kaeo, Kanchanaburi, Ranong, Phang Nga, Nan, Uttaradit, Phuket, and Lop Buri are the ten provinces with the fastest average download speeds, while Bangkok ranks 11th³¹. The following reasons explain why the ten provinces with the highest density of fiber optic networks are not in the top 10 for download speed: 1) high traffic volume but limited capacity 2) operators are unable to deploy fiber optic networks in the numerous high-rise buildings and private areas of major cities, preventing users from accessing gigabit speeds. 3) in those large cities, fixed broadband access via legacy technologies such as copper and coaxial cable is still available.

3.3 Thailand's Internet Bandwidth

3.3.1 Internet Bandwidth Volume

According to statistics on Thailand's internet bandwidth usage from the NBTC and the National Electronics and Computer Technology Center: NECTEC, internet bandwidth usage has increased rapidly over the last two decades, particularly for international internet bandwidth usage. Since 2017, international internet bandwidth consumption has exceeded domestic consumption due to increased demand for content from major content and cloud providers with servers in other countries, such as Google, Facebook, Amazon, and Microsoft.

By the end of 2020, Thailand's international internet bandwidth was 14.1 Tbps, while domestic internet bandwidth was 9.1 Tbps, a ratio of 60:40 approximately.



³¹Thailand internet speed, Speedtest by Ookla, 2020

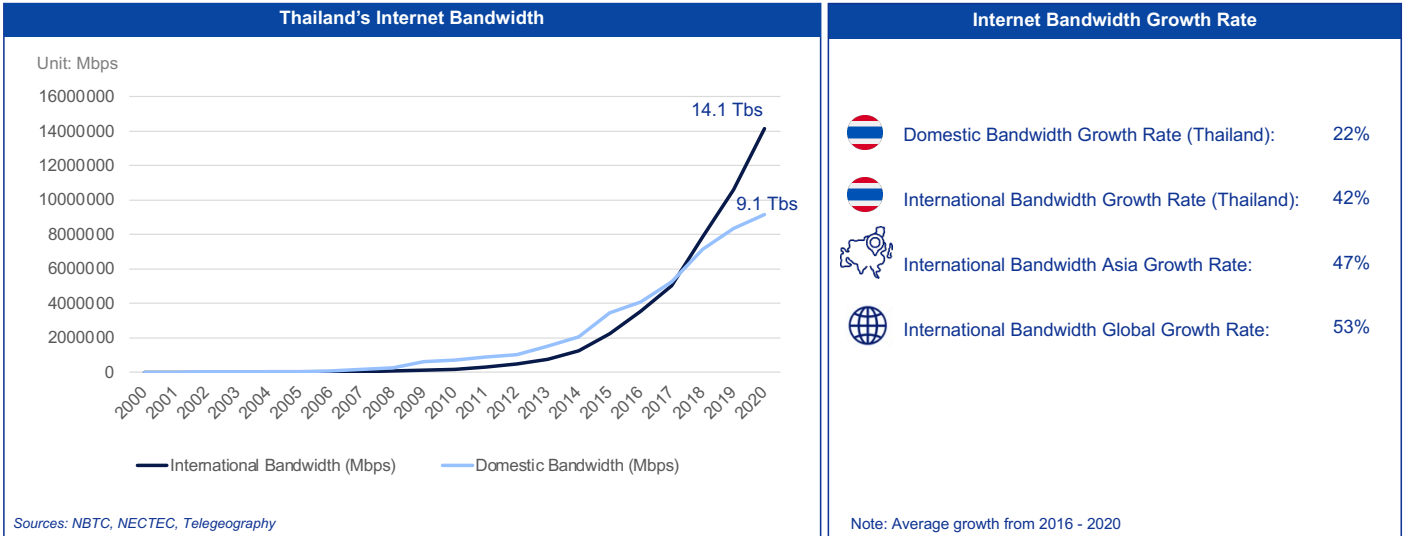


Figure 3-7: Thailand's Internet Bandwidth and Its Growth Rate in The Asia Region and Globally

According to Thailand's internet bandwidth growth rate over the past 5 years, the domestic internet bandwidth growth rate was 22%, while the international bandwidth growth rate was 42%. However, Thailand's international bandwidth growth rate remained lower than that of Asia and global, which were 47% and 53%, respectively.

3.3.2 The Usage Volume of International Internet Bandwidth per User

The volume of international internet bandwidth is a proxy for user growth and the evolution of a country's broadband internet access. International internet bandwidth per internet user is one of the indicators used to determine the ICT Development Index: IDI ranking, specifically in the section on ICT Access.



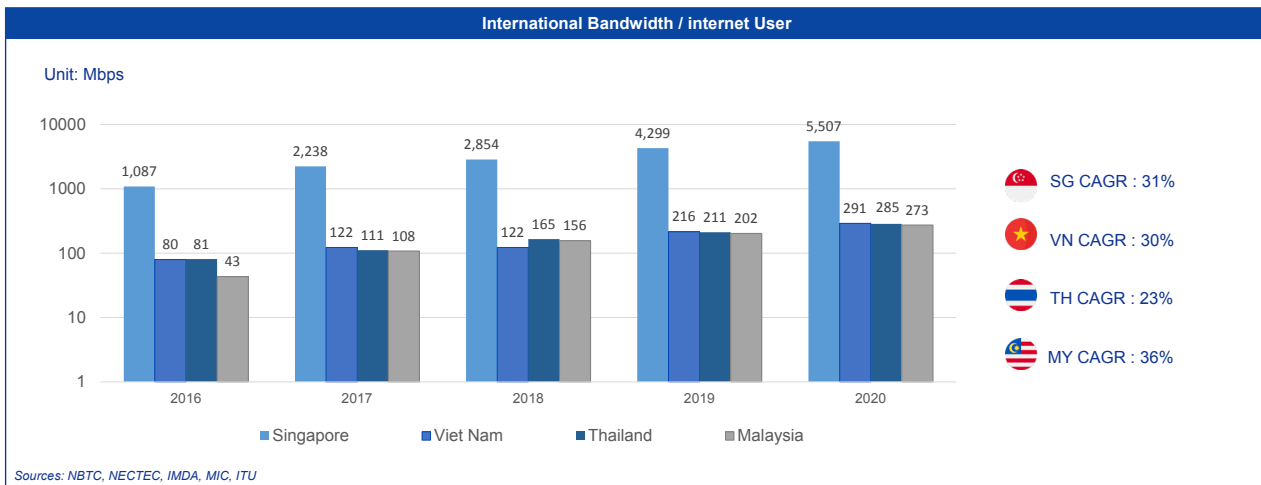


Figure 3-8: Comparing The International Bandwidth per Internet User

According to figure 3-8, the international internet bandwidth per user in Thailand is 285 Mbps at present, which is comparable to Vietnam and Malaysia. However, Thailand's international internet bandwidth growth rate has risen at a CAGR of 23%, which is lower than that of Vietnam, Singapore, and Malaysia, which have increased at CAGRs of 30%, 31%, and 36%, respectively. Singapore has had incredibly high international internet bandwidth per internet user for the past 5 years and, it is still a growing continually.

In conclusion, as shown in a comparison of Thailand's international bandwidth per internet user in the region, it was found that Thailand should accelerate the improvement of ICT accessibility in order to boost the amount of internet bandwidth usage.



3.3.3 Internet Gateway Providers and Internet Exchange Centers

Presently, Thailand has 11 international internet gateway and 13 domestic internet gateway service providers including internet Exchange Points (IXP), which consist of internet service providers, fixed and mobile network operators.

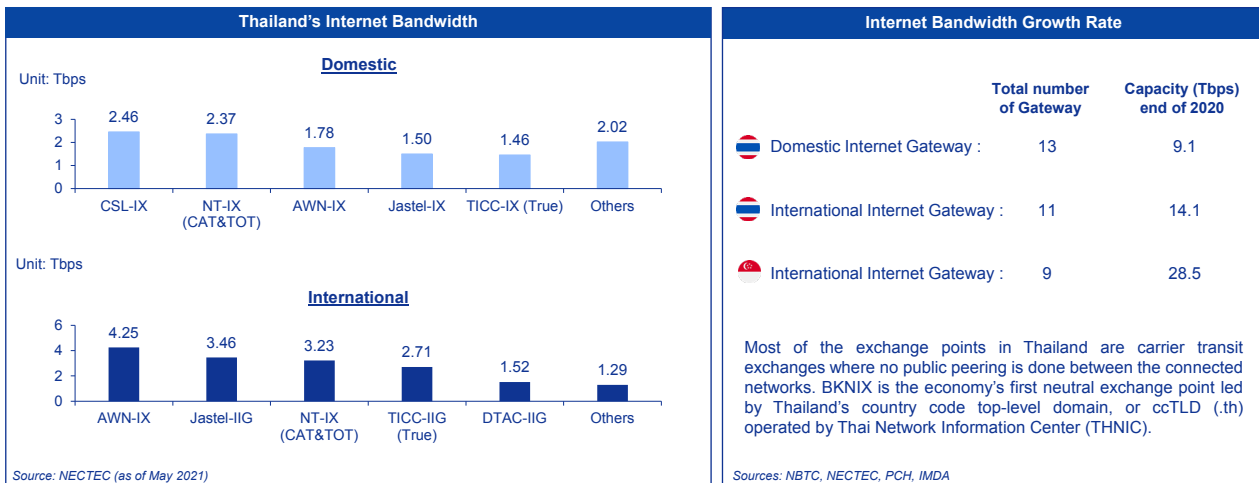


Figure 3-9: Comparing The International Bandwidth per Internet User

CSL, NT, AWN, Jastel, and TICC are Thailand's top 5 domestic internet gateways by bandwidth capacity, out of a total of 13, the majority of which are fixed broadband operators (except CSL). Their capacity accounts for approximately 80% of Thailand's domestic capacity gateways, with a combined capacity of approximately 11.6 Tbps (Data updated as of May 2021).

Thailand currently operates 11 international internet gateways. The 5 International internet Gateways with the most bandwidth capacity are AWN, Jastel, NT, TICC, and DTAC. They are all network operators, both fixed and mobile. They account for more than 80% of Thailand's international capacity gateways, with a combined capacity of approximately 16.5 Tbps (Data updated as of May 2021). As the comparison between Thailand and Singapore on the volume of international bandwidth usage, shows Thailand's international bandwidth is equivalent to 49% of Singapore's.

Although there are many internet gateway service providers in Thailand, the majority of internet Exchange Points in Thailand are for the exchange of information between broadband internet service providers, rather than for the public exchange of information between connected networks. BKNIX is the economy's first neutral internet Information Exchange Point (IXP) led by Thailand's country code top-level domain or ccTLD (.th) operated by the Thai Network Information Center Foundation (THNIC).

3.4 Indicators for The Development of Information and Communication Technology (ICT)

3.4.1 Network Readiness Index (NRI)

The Network Readiness Index (NRI) is a global indicator on the technology readiness level and communication development, as well as the potential for utilizing information and communication technology (ICT) in the public, private, and government sectors. It is produced by the Portulans Institute. Thailand's NRI was ranked 51st in the 2020 NRI report, with a total score of 53.45, an increase of five places from 2019. Thailand, on the other hand, was ranked lower than developed countries³² such as Denmark, the United States, the United Kingdom, and Japan, as well as developing countries³³ such as Singapore, South Korea, China, and Malaysia. The NRI ranking performances are based on 4 pillars: Technology, People, Governance, and Impact for example the impact on economy and the impact on quality of life. In figure 3-10, Thailand ranks lower than the average of Asia-Pacific region (APAC) in three pillars: Technology, People, and Impact. Therefore, Thailand shall strengthen these three pillars in order to improve its readiness to use information and communication technology.

³²Country Classification, UN, 2020

³³Loc. cit.

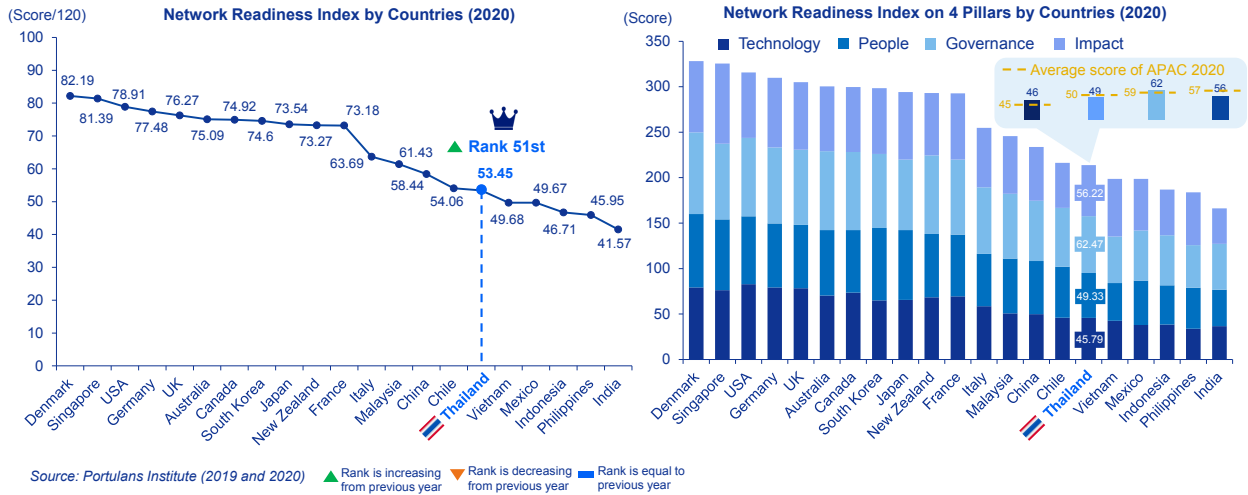


Figure 3-10: Thailand’s NRI Ranking Compared to International Countries

3.4.2 Global Connectivity Index (GCI)

The Global Connectivity Index (GCI) was conducted by Huawei to demonstrate how digital transformation in the industrial sector is enhancing each country’s potential, economy, and competitiveness. Thailand’s GCI was ranked 46th in the 2020 GCI report, with a total score of 46, a three-place improvement over 2019. Thailand, on the other hand, was ranked low in comparison to developed nations such as the United States, Denmark, the United Kingdom, and Japan, as well as developing nations such as Singapore, South Korea, China, and Malaysia. The CGI ranking is based on their performance across four distinct pillars: Supply, Demand, Experience, and Potential, each with ten sub-indicators, for a total of forty. Fixed broadband service has four sub-indicators: FTTH Subscriptions, Fixed Broadband Subscriptions, Fixed Broadband Affordability, and Broadband Potential. Thailand performs worse than the average in three sub-indicators depicted in Figure 3-11: Fixed Broadband Subscriptions, Fixed Broadband Affordability, and Broadband Potential. As a result, Thailand’s future competitiveness depends on strengthening these three indicators.

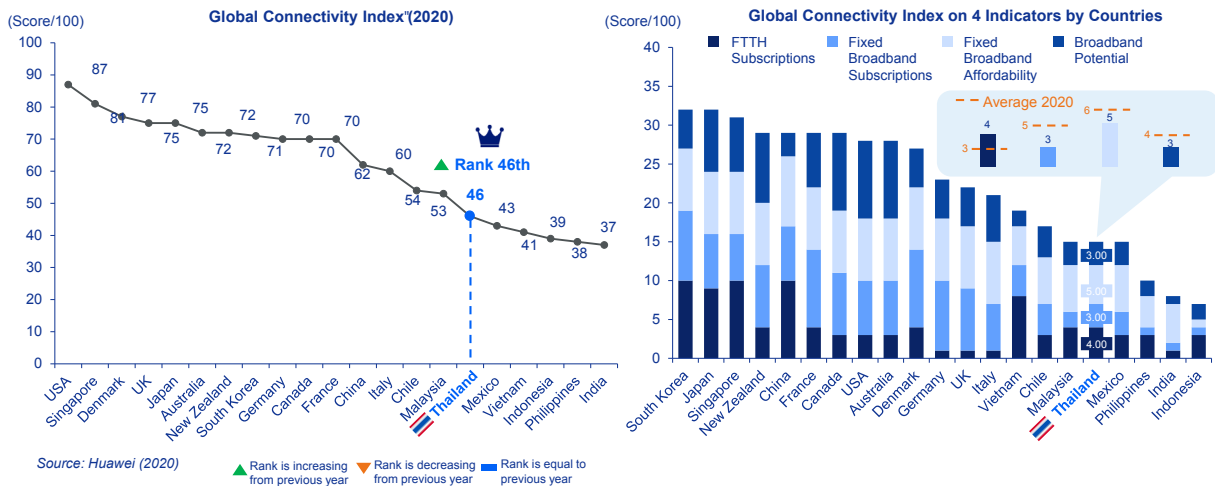


Figure 3-11: Thailand's GCI Ranking Compared to International Countries

3.4.3 World Competitiveness Ranking on Technological Infrastructures

The IMD's World Competitiveness Ranking measures the worldwide competitiveness of 64 economic areas. The IMD's World Competitiveness Ranking 2021 employs criteria to classify 338 indicators into four pillars: 1) Economic Performance (81 sub-indicators), 2) Government Efficiency (72 sub-indicators), 3) Business Efficiency (74 sub-indicators) and 4) Infrastructure (107 sub-indicators). Thailand focuses on technological infrastructure indicators in the infrastructure pillar.

In 2021, it ranked 37th on indicators of technological infrastructure, trailing developed countries such as the United States, Denmark, the United Kingdom, and Japan, as well as developing countries such as Singapore, China, South Korea, and Malaysia. Thailand's technological infrastructure ranking has fallen three places since 2020, owing to a decline in public and private support for technology development, as well as an increase in the cost of telephone service indicator³⁴. As a result, Thailand's technological infrastructure needs to improve in order to support increased utilization of digital technology infrastructure in the future as well as to enhance the company's future competitiveness.

³⁴Summary of IMD World Competitiveness Ranking, The Secretariat of the Cabinet, 2021

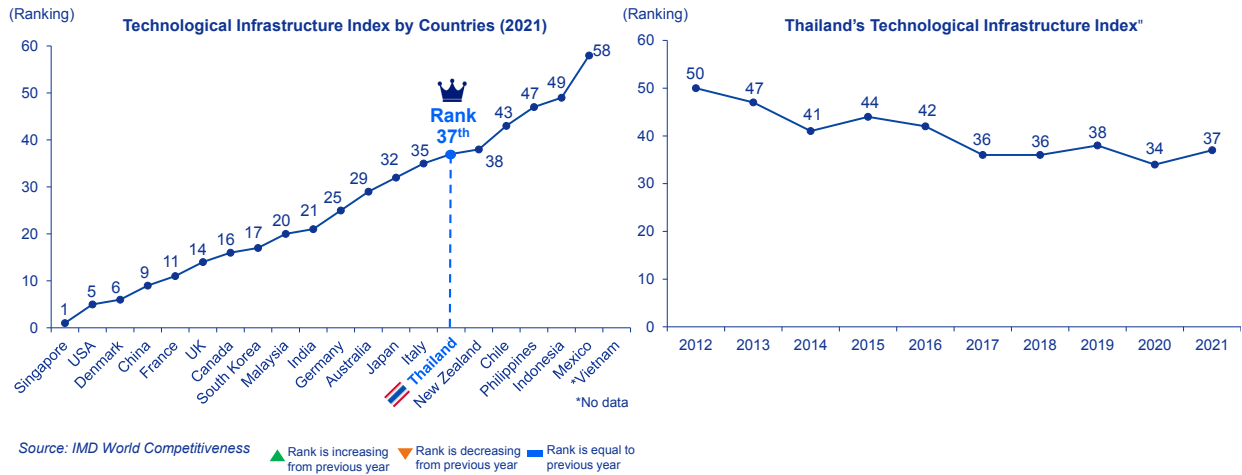
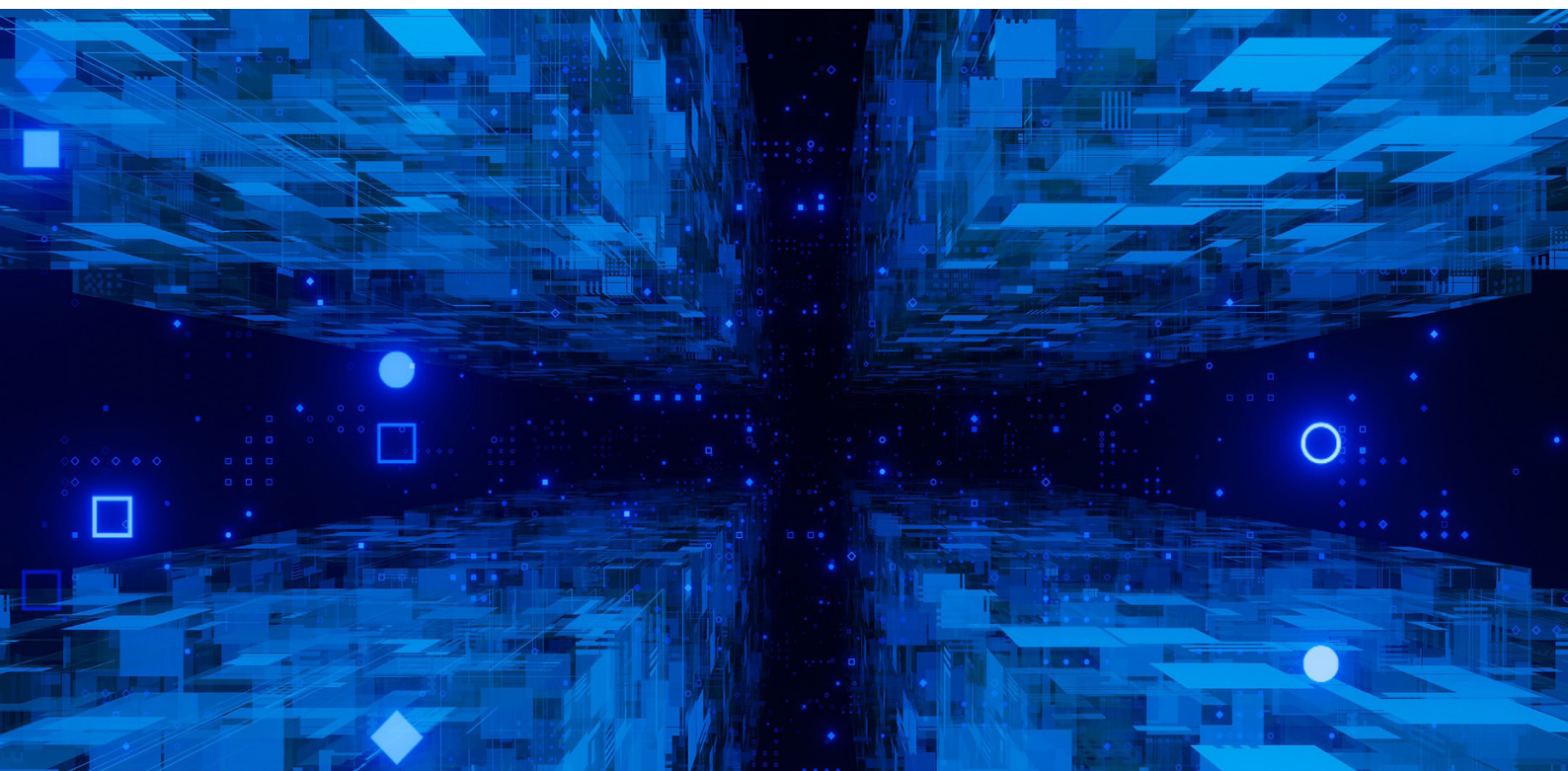


Figure 3-12: Thailand's IMD World Competitive Ranking on Technological Infrastructure Indicators Compared to International Countries

Thailand is ranked in the middle of international countries on the NRI, CGI, and Technological Infrastructure indicators. It must improve the NRI across three pillars: 1) technology 2) people, and 3) impact, as well as the GCI across three indicators: fixed broadband subscriptions, fixed broadband affordability, and broadband potential, as well as the World Competitive Ranking across technological infrastructure indicators, in order to increase readiness for the use of information and communication technology and to encourage increased utilization of digital technology infrastructure. As a result, Thailand's global competitiveness will improve.



3.5 Comparing Thailand's Fixed Broadband with International Countries

Thailand has been steadily increasing the availability of fixed broadband services. To improve its fixed broadband services, Thai telecommunications statistics were compared to those of 20 selected countries on four pillars. The twenty countries chosen are at the forefront of fiber optic network development in the region, as follows: 1) France, the United Kingdom, Germany, Spain, and Sweden are five selected European countries. 2) Republic of China (or China), South Korea, Japan, the United Arab Emirates, Singapore, Australia, and New Zealand are the seven Asian countries selected. 3) The United States, Canada, Mexico, and Chile are the four selected American countries. 4) Malaysia, Vietnam, Indonesia, and the Philippines are the four ASEAN countries leading the deployment of fiber optic technology. The following are the four pillars: 1) fiber penetration by households 2) fiber subscriptions growth rate 3) fixed broadband speeds and 4) fixed broadband service price of GNI per capita (Gross National Income).

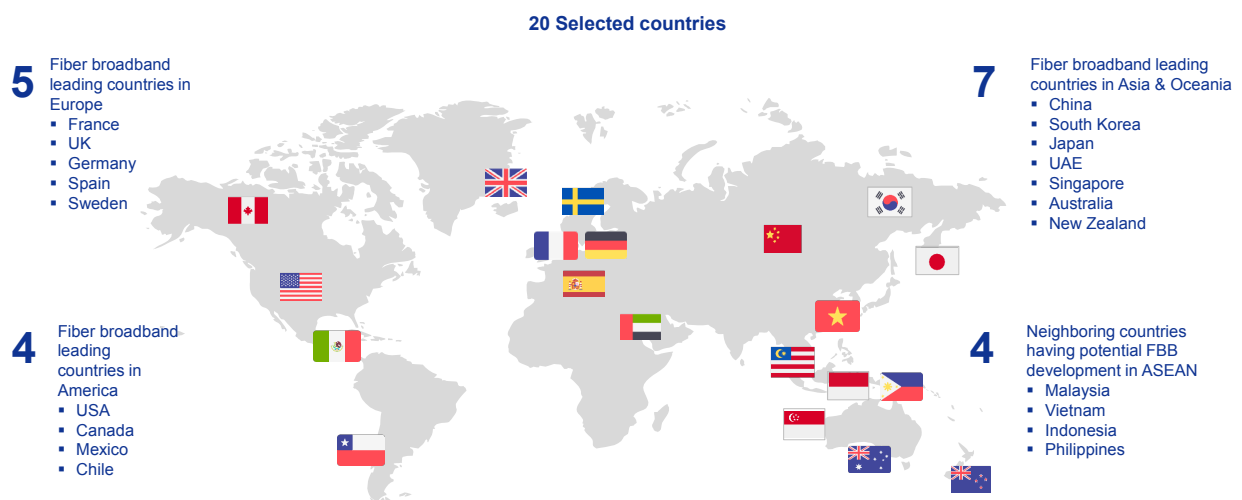
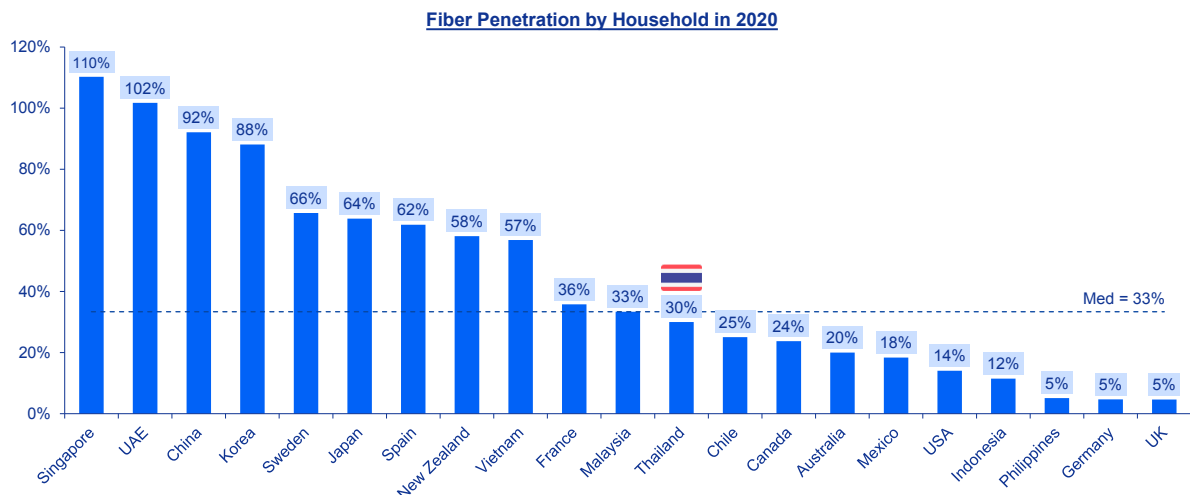


Figure 3-13: The Selected Countries for Comparing in Fixed Broadband with Thailand

3.5.1 Comparison of Fiber Penetration by Households

In 2020, the fiber penetration by households in Thailand was 30%³⁵, while the median of 20 selected countries was 33%³⁶. Thailand has a lower fiber penetration by households than the median of 20 selected countries, indicating that Thailand should improve in this pillar.

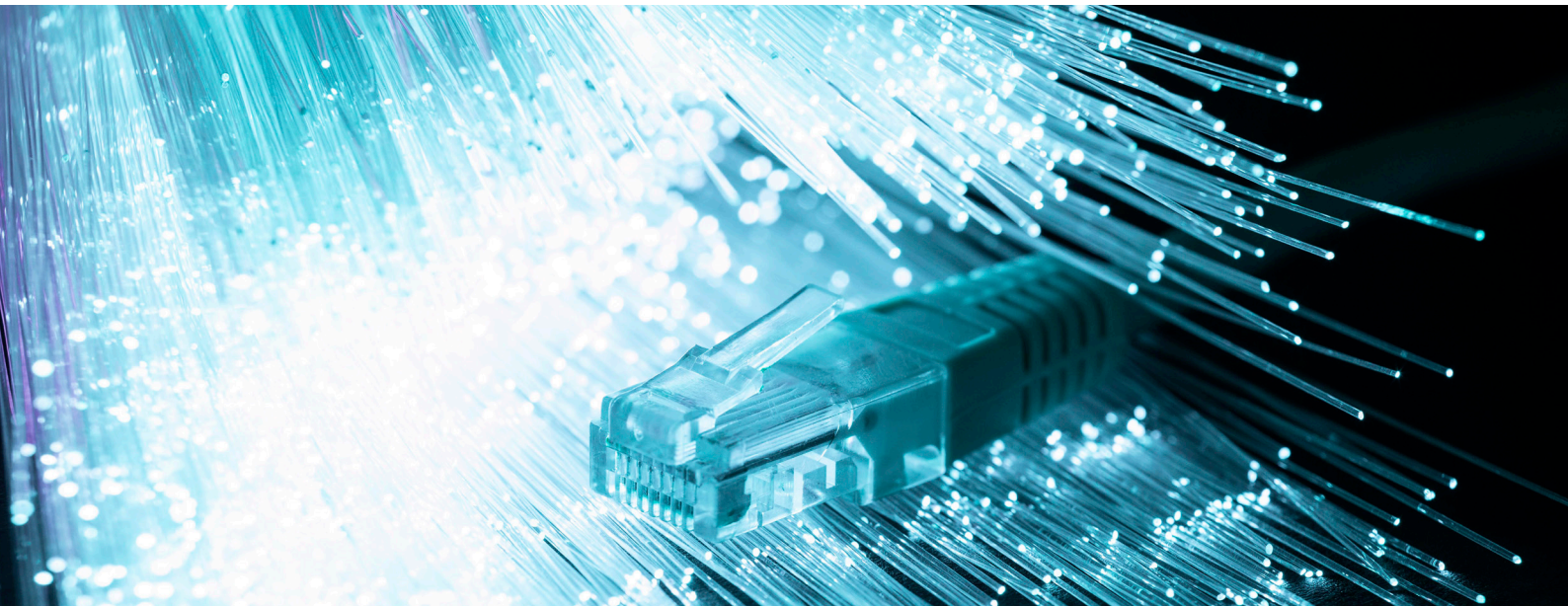


Sources: CAICT (2020), GSO's Vietnam (2020), NBTC (2020), IDATE for FTTH Council MENA (2020), IMDA (2019&2020), MCMC (2020), National Statistic Office in Each Country (2020), NTC's Philippines (2020), OECD (2020), World Bank (2020)

Figure 3-14: Comparing Thailand's Fiber Penetration by Households with International Countries

³⁵Calculating from Thai Telecom Industry Database, NBTC, 2020

³⁶Calculating from 1) Fiber broadband penetration, CAICT, 2020 2) Fiber subscription, OECD, 2020 3) FTTH council MENA - Panorama, IDATE Digiworld, 2020 4) ICT statistics and household data, National Statistic office in Each Country, 2020 5) Telecom statistics, GSO's Vietnam, 2020 6) Telecom statistics, IMDA, 2020 7) Telecom statistics, MCMC, 2020 8) Telecom statistics, NTC's Philippines, 2020 9) Telecom statistics, World Bank, 2020 10) Thai Telecom Industry Database, NBTC, 2020



3.5.2 Comparison of the Fiber Subscriptions Growth Rate

Between 2019 and 2020, Thailand's fiber subscription growth rate was 2%, compared to a median of 15%³⁷ in 20 selected countries. Thailand's growth rate is faster than the median of 20 selected countries.

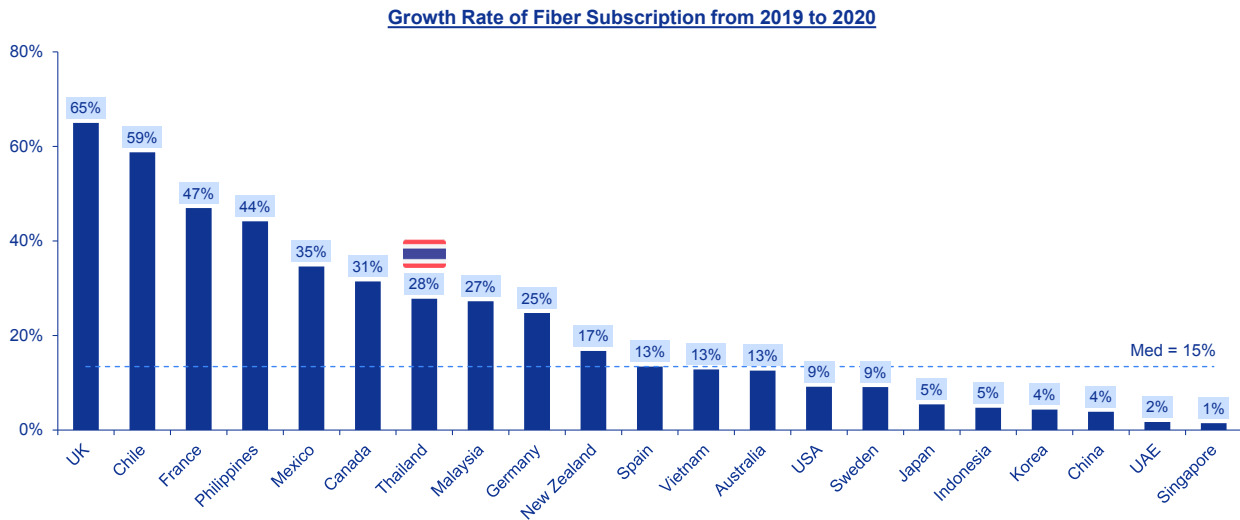


Figure 3-15: Comparing Thailand's Fiber Subscriptions Growth Rate with International Countries

³⁷Calculating from 1) Fiber broadband penetration, CAICT, 2019-2020 2) Fiber subscription, OECD, 2019-2020 3) FTTH council MENA - Panorama, IDATE Digiworld, 2019-2020 4) ICT statistics and household data, National Statistic office in Each Country, 2019-2020 5) Telecom statistics, GSO's Vietnam, 2020 6) Telecom statistics, IMDA, 2019-2020 7) Telecom statistics, MCMC, 2019-2020 8) Telecom statistics, MIT's Vietnam, 2019 9) Telecom statistics, NTC's Philippines, 2019-2020 10) Telecom statistics, World Bank, 2019-2020 11) Thai Telecom Industry Database, NBTC, 2019-2020



3.5.3 Comparison of the Fixed Broadband Speeds

The average fixed broadband speeds for downloading and uploading in Thailand was 191/151 Mbps³⁸ in 2020, while the average of 20 selected countries is 123/83 Mbps³⁹. Thailand has a faster fixed broadband speed than the average of 20 selected countries and ranks 2nd for fixed broadband download speed.

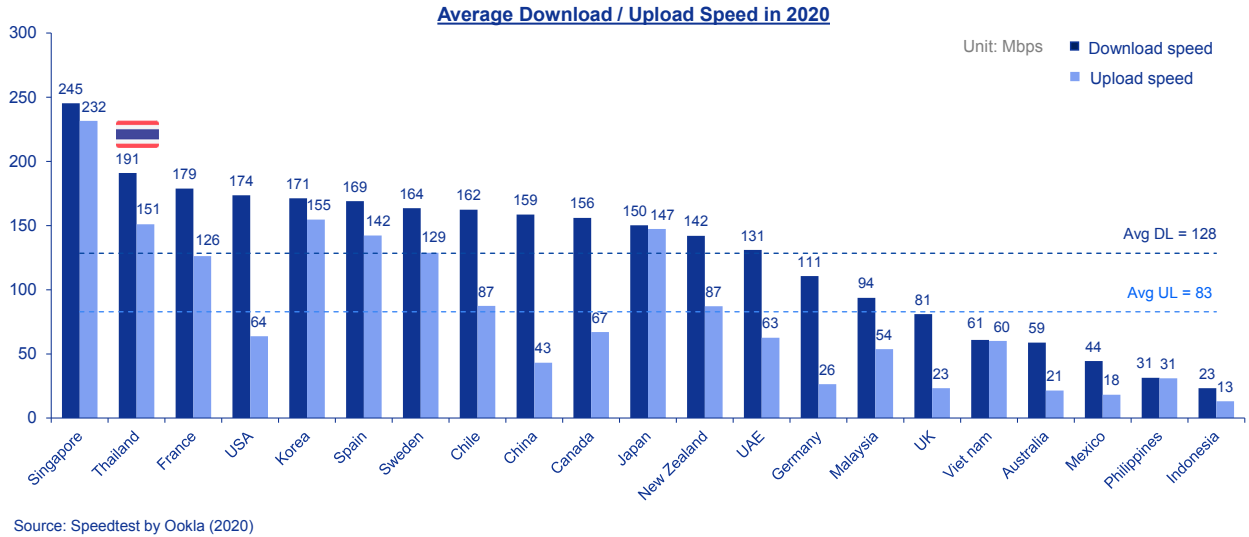


Figure 3-16: Comparing Thailand’s Average Fixed Broadband Speed with International Countries

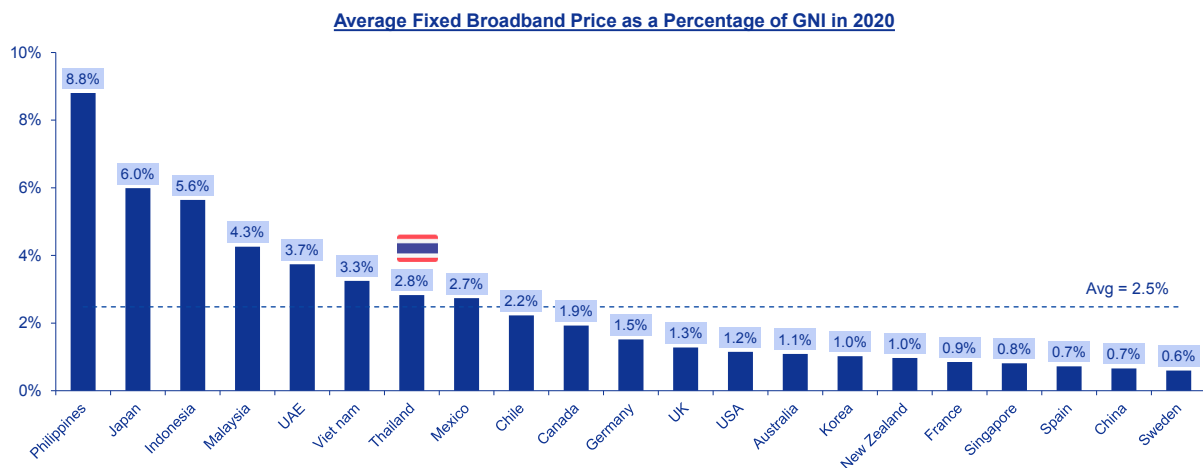
³⁸Global Index, Speedtest by Ookla, 2020

³⁹Calculating from Global Index, Speedtest by Ookla, 2020



3.5.4 Comparison of Fixed Broadband Service Price of GNI per Capita

The fixed broadband service price as a percentage of GNI per capita in Thailand is 2.83%⁴⁰, while the average of 20 selected countries is 2.5%⁴¹. Thailand has higher fixed broadband service prices of GNI per capita than the median of 20 selected countries, indicating that Thailand should improve this pillar.



Sources: Annual Report of Largest Operator in Each Countries (2020), Fixed broadband ARPU, Global Data(2020), National Telecom Statistics in Each Countries (2020), World Bank(2020)

Figure 3-17: Comparing Thailand's Fixed Broadband Service Price of GNI per Capita with International Countries

⁴⁰Calculating from 1) Thailand GNI, World Bank, 2020 2) Telecom market, NBTC, 2020 3) Fixed broadband ARPU, annual report of each operator, 2020

⁴¹Calculating from 1) GNI, World Bank, 2020 2) ARPU, Global Data, 2020 3) Fixed broadband ARPU, Annual Report of Largest Operator in Each Countries, 2020 4) Fixed broadband market, National Telecom Statistics in Each Countries, 2020



3.6 The Challenges of Thailand's Fixed Broadband Development

The difficulties encountered of Thailand's fixed broadband development can be classified into three categories: coverage, speed, and accessibility, which vary according to urban and rural areas. Additionally, the disparity in the development of fixed broadband between urban and rural areas creates a digital divide. The following are the challenges and issues surrounding the digital divide in each topic:

1) Challenge in Coverage areas: Urban areas: Costs associated with deployment in urban areas when using an underground duct. Additionally, exclusive operators restrict access to private areas, such as residential buildings and housing estates, to other operators. Rural areas: The public Wi-Fi solution has a limited coverage area. Individual houses have a lower fiber connection. Broadband digital divide: While most urban households have access to the internet via fiber optic networks, the majority of rural households do not, forcing rural residents to connect via public Wi-Fi, demonstrating that there are some gaps in both availabilities. It demonstrates that most of the fiber penetration by households (30%) occurs in cities⁴².

2) Challenges in Speed: Urban areas: Legacy technology is a barrier to upgrade speed, a strategy to replace copper and coaxial cables inside the old buildings in the big cities is required. Rural areas: The public Wi-Fi solution limits the speed depending on the number of users and the distance from the access point. Broadband digital divide: The average DL/UL speed in urban areas is 191/151 Mbps⁴³, whereas the speed in rural areas is 30/10⁴⁴ – 100/50 Mbps.⁴⁵

⁴²Thai Telecom Industry Database, NBTC, 2020

⁴³Global Index, Speedtest by Ookla, 2020

⁴⁴Loc. cit.

⁴⁵The village broadband internet project, MDES, 2019

3) Challenges in accessibility: Rural areas: Low-income households in rural areas struggle to afford the cost of broadband internet using. A lack of sufficient knowledge makes it difficult to gain access to digital content. Broadband digital divide: There is a difference between the percentage of broadband internet user penetration in urban and rural areas, as shown in Figure 3-18.⁴⁶ The low percentage of broadband internet user penetration in rural reflects the overall country's low percentage of broadband internet user penetration.

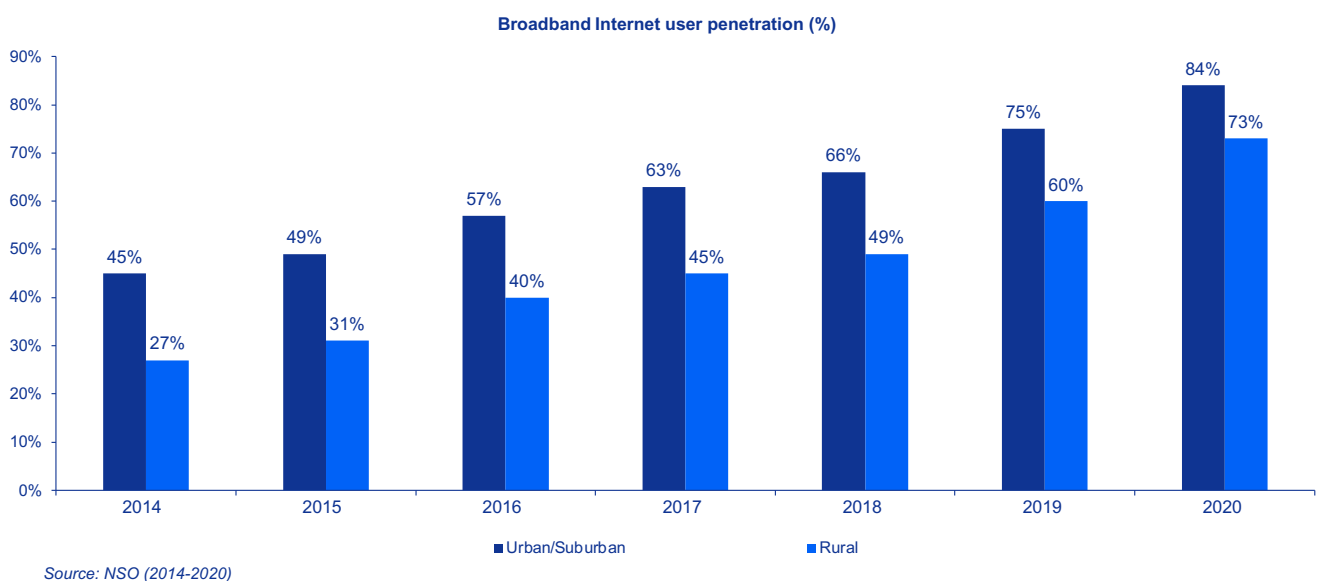


Figure 3-18: Broadband Internet User Penetration between Urban and Rural

⁴⁶Broadband internet user penetration between urban and rural, NSO, 2014-2020



4 Comparative Studies on The Development of Fixed Broadband in Leading Countries

4.1 The People's Republic of China



In 2013, the People's Republic of China (or China) launched "The Broadband China Strategy Plan⁴⁷" to address the country's fixed broadband development challenges, in term of lower fixed broadband penetration and speed than developed countries, as well as the broadband digital divide between urban and rural areas. Over 100 countries have already developed a strategy for broadband development. This has prompted China to initiate this plan. The development of fixed broadband is a priority objective of China's 12th Five-Year Plan for Economic and Social Development. Three phases define China's fixed broadband development objectives:

- ◆ Phase 1: By 2013, fixed broadband speeds will increase from 2 Mbps to 20 Mbps.
- ◆ Phase 2: By 2014 – 2015, the fiber optic broadband coverage will reach 80% of the country.
- ◆ Phase 3: By 2016 – 2020, fixed broadband will have a speed of more than 100 Mbps, and gigabit network will be covered in major cities. The gigabit network will cover the entire country after 2020.

⁴⁷Broadband China Strategy, CAICT, 2014

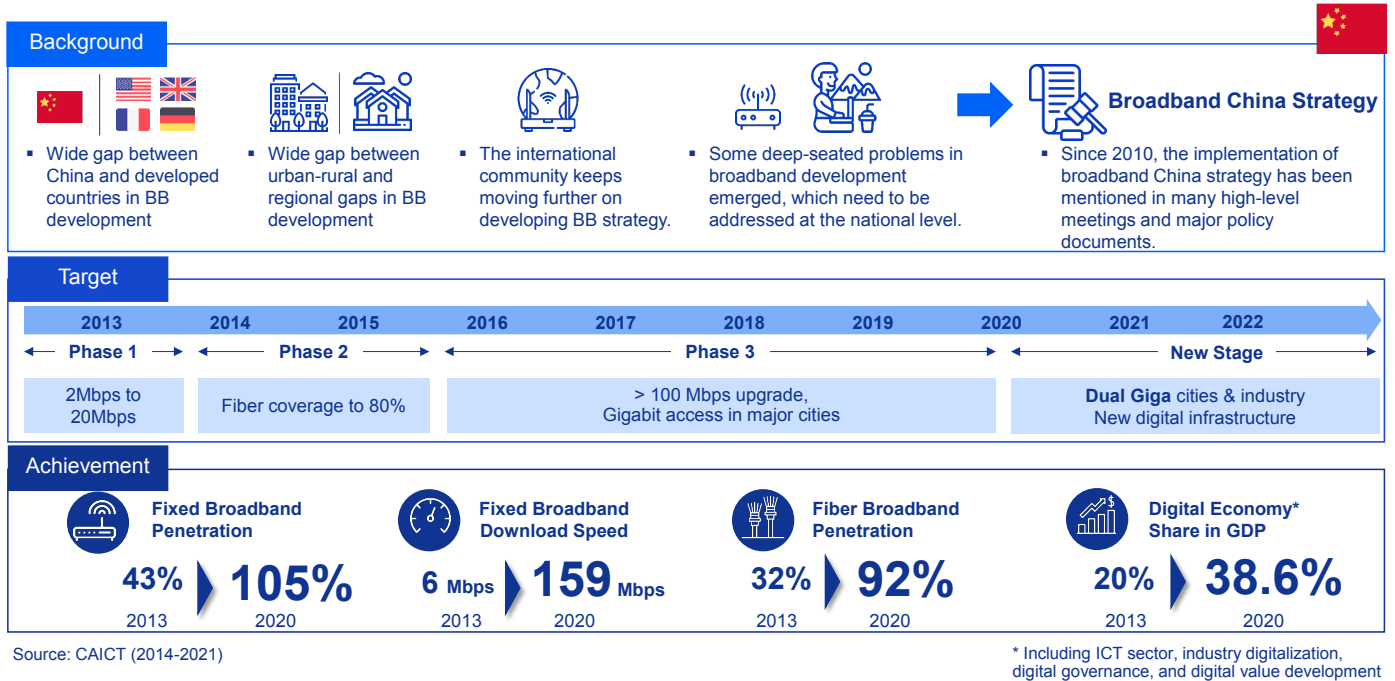


Figure 4-1: Targets and Plans for China's Fixed Broadband Development

China's broadband strategy plan has achieved four aspects: 1) fixed broadband penetration by households grew from 43% to 105% in 2013 and 2020 respectively 2) fixed broadband download speed increased from 6 Mbps to 159 Mbps in 2013 and 2020 3) fiber broadband penetration by households increased from 32% in 2013 to 92% in 2020 and 4) digital economy contribution to GDP grew from 20% in 2013 to 38.6% in 2020.

Additionally, China has developed "The Dual Giga Initiative Plan" with 5 targets by 2025 as described previously in Chapter 2: 1) Gigabit cities will expand to 100 cities 2) Gigabit fiber optic network will cover 400 million households 3) XG-PON ports will be increased to 10 million ports 4) Gigabit subscribers will increase to 30 million households and 5) 5G network will cover all villages. At the moment, FTTH port usage is 1.8 ports per household (based on 0.92 billion FTTH/O ports from 0.51 billion households⁴⁸). Additionally, in 2021, the People's Republic of China will adopt FTTR (Fiber to The Room) for 30,000 households⁴⁹.

⁴⁸China Broadband Development Whitepaper No.202113, CAICT, 2021

⁴⁹Loc. cit.

However, to support the increase in fixed broadband penetration, the operators should expand their optical transport network (OTN). In 2020, the OTN node ratio was 0.54 nodes per 10,000 users, and it aims to increase to 2 nodes per 10,000 users in the next two years, and 4 nodes per 10,000 users in the future⁵⁰.

4.2 France



In 2011, France launched “The National Program for Very High-Speed Broadband Plan”, covering a period more than 14 years, to expand fixed broadband coverage to entire country and to increase fixed broadband penetration rate since France lags behind other EU countries in terms of broadband development. The EU broadband coverage 2011 report shows that France’s next generation access (NGA) was ranked 26th⁵¹ or around 39%, below the average at 50%. Moreover, fixed broadband service zones are centered only in metropolitan areas. France is lack of infrastructure sharing, causing development of this plan with the four targets: 1) providing fixed broadband speeds higher than 512 Kbps to cover all of population by 2012. 2) providing fixed broadband speeds higher than 8 Mbps to cover all of population by 2020. 3) providing fixed broadband speeds higher than 30 Mbps to cover all households and extending fiber optic network to cover 80% of households by 2022 and 4) extending fiber optic network to cover 100% of households by 2025.

⁵⁰All Optical Smart City Development 2.0 Report, CAICT, 2021

⁵¹Broadband Coverage Report, EU, 2011

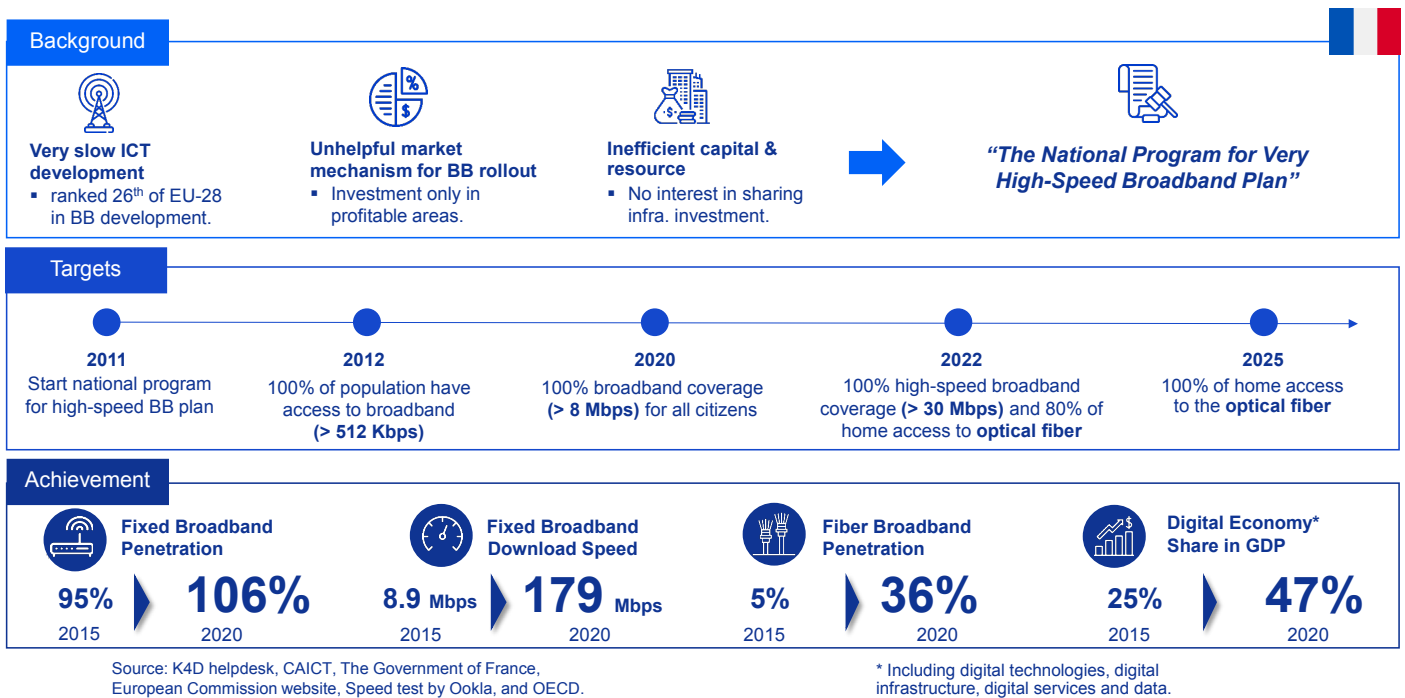


Figure 4-2: Targets and Plans for France's Fixed Broadband Development

France's broadband development plan has achieved four aspects: 1) fixed broadband penetration by households grew from 95% in 2015 to 106% in 2020. 2) fixed broadband download speed increased from 8.9 Mbps in 2015 to 179 Mbps in 2020. 3) fiber broadband penetration by households increased from 5% in 2015 to 36% in 2020 and 4) digital economy contribution to GDP grew from 25% in 2015 to 47% in 2020.

4.3 Singapore



In 2005, Singapore launched “The Intelligent Nation Plan” (iN 2015), which was implemented more than 10 years, to catalyze significant economic shifts due to Singapore's natural resource scarcity. It is critical to develop a competitive edge through the development of telecommunications. The development of the next generation nationwide broadband network (Next Gen NBN) through fiber optics is an important part of this plan. Although Singapore's fixed broadband penetration was 81% of households, fiber broadband penetration was still low. It has set targets

for expanding fiber optic coverage to more than 50% of households and businesses by 2012 and higher than 95% of households and businesses by 2015. From the Next Gen NBN project since 2009, Singapore’s fiber optic coverage was higher than 60% of households and businesses in 2010 and higher than 95% in mid-2012, exceeding the targets earlier than planned

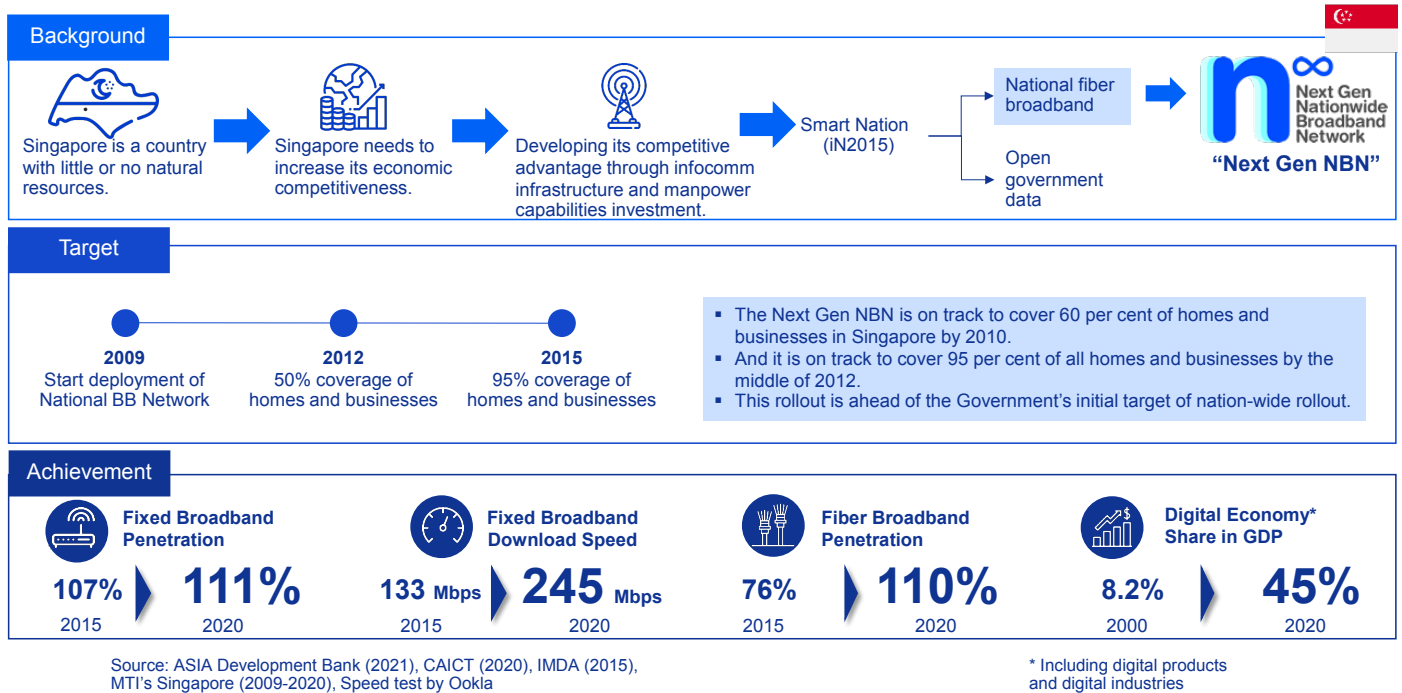


Figure 4-3: Targets and Plans for Singapore’s Fixed Broadband Development

Singapore’s broadband development plan has achieved four aspects:

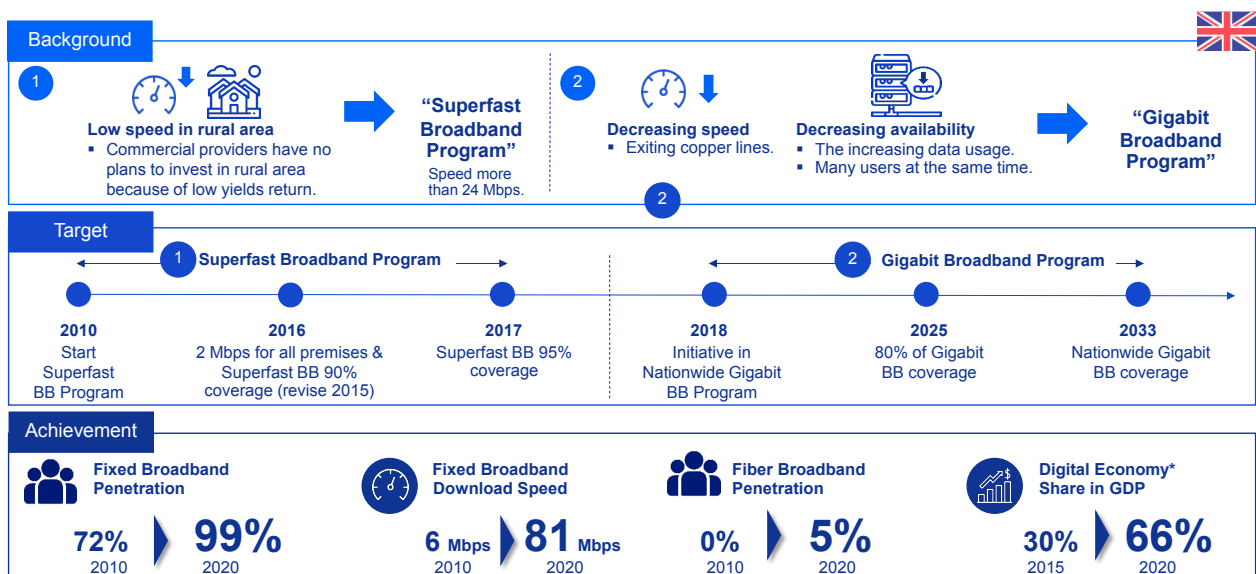
- 1) fixed broadband penetration by households grew from 107% in 2015 to 111% in 2020.
- 2) fixed broadband download speed increased from 133 Mbps in 2015 to 245 Mbps in 2020.
- 3) fiber broadband penetration by households increased from 76% in 2015 to 110% in 2020 and
- 4) digital economy contribution to GDP grew from 8.2% in 2000 to 45% in 2020.

4.4 The United Kingdom



In 2010, the United Kingdom launched a plan to develop broadband services in rural areas where no service provider was willing to invest in. As a result, the country established the “Superfast Broadband Program 2010–2017” to expand broadband service.

In the United Kingdom, “superfast” broadband is defined as internet connectivity that is faster than 24 Mbps. This plan aims to provide fixed broadband connectivity at a minimum speed of 2 Mbps to all premises. By 2016, fixed broadband will cover 90% of the country (the target was changed from 2015 to 2016), and 95% by 2017. Following the completion of the project, the United Kingdom’s fixed broadband suffered from the use of copper wire technology and an increase in fixed broadband users, resulting in increased data demand and decreased capacity. As a result, the “Gigabit Broadband Program 2018” was established with the goal of covering 80% of the country with gigabit broadband by 2025 and 100% by 2033.



Source: K4D helpdesk (2020), National Audit Office (2013-2014), OECD (2010,2020), UK Parliament (2021), Speed test by Ookla (2020)

* Including ICT sectors and digital content industry

Figure 4-4: Targets and Plans for The United Kingdom’s Fixed Broadband Development

The United Kingdom's broadband development plan has achieved four aspects: 1) fixed broadband penetration by households grew from 72% in 2010 to 99% in 2020. 2) fixed broadband download speed increased from 6 Mbps in 2010 to 81 Mbps in 2020. 3) fiber broadband penetration by households increased from 0% in 2010 to 5% in 2020 and 4) digital economy contribution to GDP grew from 30% in 2015 to 66% in 2020.



5 Policies and Targets for Thailand's Fixed Broadband Development

The development of digital infrastructure is essential for the country's overall growth. As digital expansion is critical for driving industrial value, it results in increased competitiveness and competitive advantages. Furthermore, it improves an organization's management efficiency and has the potential to reduce operating costs. In short, Thailand's economic development is contingent upon the development of its digital infrastructure. Apart from that, digital access has facilitated the exchange of knowledge and information, as well as the dissemination of vital alerts, resulting in more extensive learning. Thailand's economic and social development are inextricably linked to the development of digital infrastructure.



The development of the fixed broadband network is one of the key strategies for digital infrastructure development. Currently, Thailand has developed the policies and plans for the digital infrastructure development in the economy and society in the following phases: 1) National Digital Economy and Society Development Plan and Policy (2018–2037), 2) 5 Years of Digital Economy and Society Development Action Plan (2018–2022), and 3) the Draft of Digital Technology Infrastructure Action Plan, Phase 1 (2022–2027) which is being amended and approved at the present. Besides, NBTC have developed Thailand's Telecom Industry Plans which focus

on fixed broadband development through the following: 1) Telecommunications Master Plan No. 2 (2019–2023) which determines the NBTC’s direction of governance on telecom industry. The goal of this plan is to sustain the rapidly changing digital ecosystem environment. The plan concentrates on allocating of telecom resources to confront demand and improve the coverage of telecommunication infrastructure. 2) Universal Service Obligation Plan No.2 (2016–2021) and 3) Draft of Universal Service Obligation Plan No.3 (2022–2026), which the both aim to develop expansions of telecommunication infrastructures and high-speed internet services to all areas, to cover on all groups of the Thai population as well as government agencies’ operations. By expanding on the adoption of “Upgrading Telecommunication Infrastructure Project to Drive the National Economy Project”, a project that aims to expand high-speed internet networks to cover all of Thailand’s villages.

5.1

The UN Goals for the Development of Digital Infrastructure and Broadband

By 2019, half of the world’s population will have access to broadband internet, but the remaining half of the world’s estimated 3.8⁵² million people will be unable to benefit from digital expansion in terms of information access and social and economic development. As a result, the Broadband Commission for Sustainable Development establishes 7 goals to be achieved by 2025 in order to develop broadband internet infrastructure, expand broadband internet coverage, and increase broadband internet usage across all populations. According to UN targets, there are 2 goals regarding the development of broadband internet infrastructure in Thailand. Those 2 developing goals are the charges of broadband internet services and broadband internet access rates. The charges of broadband internet services should be less than 2% of monthly GNI per capita. The broadband internet access rates for developing countries should reach 65%⁵³.

⁵²2025 Targets: Connecting the other half, ITU, 2018

⁵³Loc. cit.

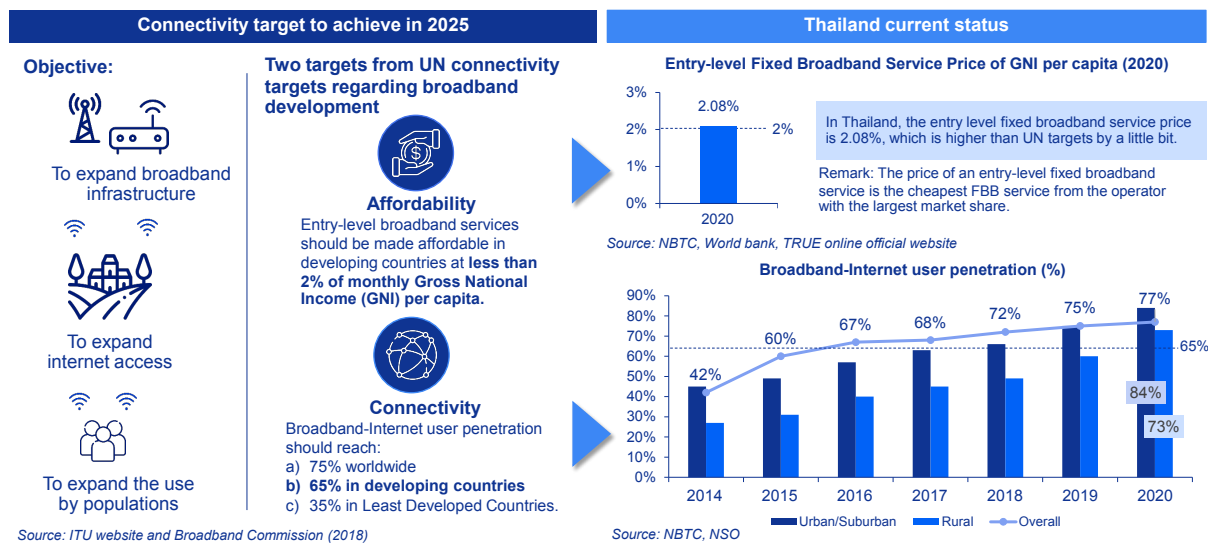


Figure 5-1: The UN Connectivity Targets 2025

Comparing the Thai fixed broadband internet service rates with the GNI per capita in 2020, it was 2.08%⁵⁴ which shows slightly higher than the target set by the UN. This service rate refers to the lowest package offering by a service provider with the highest fixed broadband market share which is higher than the UN targets. When compared to the income gap per capital between urban and rural areas, on the assumption that rural people have lower income per capita than urban people. This illustrates the cost of entry-level broadband for rural people may exceed 2.08% of monthly income.

Thailand's broadband internet user penetration rate was 77%, with urban areas was 84% and rural areas was 73%.⁵⁵ In the case comparison to the UN target of 65% for developing countries, the Thai rates in both urban and rural areas are significantly higher. Rural broadband access rates, on the other hand, are considerably lower than in cities. Thus, Thailand should improve the charges of entry-level broadband services and close the gap between urban and rural broadband internet access rates by increasing rural broadband internet access rate.

⁵⁴Calculating from 1) Thailand GNI, World Bank, 2020 2) Fixed broadband lowest internet package offering by True, Trueonline official website, 2020

⁵⁵Internet user, NBTC, 2014-2020

Due to the Covid-19 pandemic, it reinforces the need for digital technology, changing people's behaviors into the new normal lifestyle. The new normal has resulted in a variety of online activities such as in new working style, medical doctor consulting in telemedicine way, virtual studying, and ordering food and goods in a new way. The COVID-19 caused an increasing in the telecommunication network usage more than ever before, resulting in a 30% rise in internet traffic consumption⁵⁶. If the internet backbone's available capacity is less, it may not be sufficient to handle the increased internet traffic. Due to the lockdown, some data traffic migrated away from mobile networks and toward fixed/Wi-Fi networks. Additionally, remote work increases the demand for broadband internet upload speeds. This has exacerbated the issue of internet download and upload speed asymmetry.

The more using in broadband internet, the greater need for better broadband uplink speed, and the migrated data traffic from mobile to fixed/Wi-Fi networks reveal a new requirement for broadband infrastructure. Fixed broadband service should be served by fiber optic network and connected to the internet backbone with 50% of available capacity at all the time⁵⁷ in order to handle increased traffic even during peak times.

5.2 Digital Infrastructure Development Policy and Plan for Economy and Society

Thailand is currently undergoing a transition to the Thailand 4.0 age, in which the economy and society are propelled by technical and digital breakthroughs that span all sectors. Thailand's 4.0 policy prioritizes the development of digital technology infrastructure. As a result, the Thai government launched "The National Digital Economy and Society Development Plan and Policy (2018–2037)," "The Digital Economy and Society Development Action Plan (2018–2022)," and the Draft "Digital Technology Infrastructure Action Plan Phase 1 (2022–2027)" for the development of digital technology infrastructure.

⁵⁶Economic impact of covid-19 on digital infrastructure, ITU, 2020

⁵⁷ITU loc.cit.

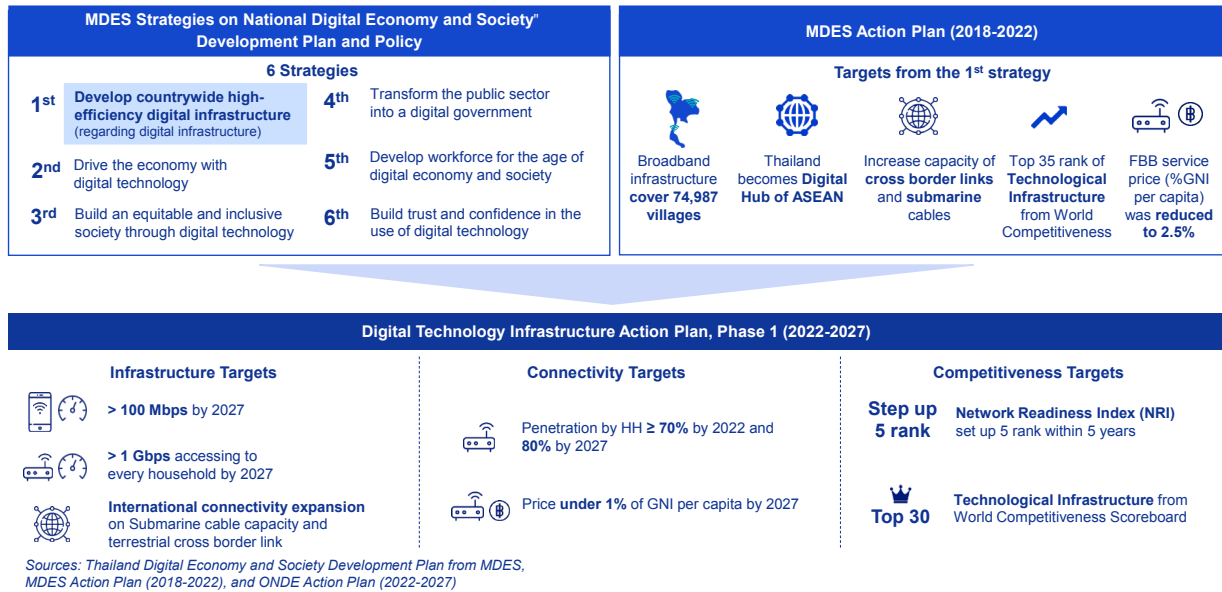


Figure 5-2: Fixed Broadband Development Policies And Goals for The Economy and Society

5.2.1 The National Digital Economy and Society Development Plan and Policy

The National Digital Economy and Society Development Plan and Policy (2018–2037) is Thailand’s principal master plan for the development of the digital economy and society. Through the employment of digital technology, it sets the course for the country’s sustainable growth, and this plan consists of six strategies as follows: 1) develop countrywide high-efficiency digital infrastructure 2) drive the economy with digital technology 3) build an equitable and inclusive society through digital economy 4) transform the public sector into a digital government 5) develop workforce for the age of digital economy and society and 6) build trust and confidence in the use of digital technology. It reasons the first strategy is critical for establishing fixed broadband plans: develop a countrywide high-efficiency digital infrastructure. However, due to the rapid advancement of digital technology, this plan identifies targets and directions for the growth of the digital economy and society divides into four phases:

- ◆ Phase 1 (1 year 6 months) Digital Foundation: Investing and building digital foundation.
- ◆ Phase 2 (5 years) Digital Thailand I: Inclusion; Ensuring all Thai sectors can benefit from digital technologies.

- ◆ Phase 3 (10 years) Digital Thailand II: Full Transformation; Driving and maximizing the potential of the country's digital technologies and innovation.
- ◆ Phase 4 (10–20 years) Global Digital Leadership; Leading with digital technology and innovation (becoming a developed country).

5.2.2 Digital Economy and Society Development Action Plan (MDES)

MDES Action Plan 5 Years (2018–2022) is a five-year action plan developed in accordance with The National Digital Economy and Society Development Plan and Policy from MDES (2018–2037), which is related with goals for the growth of the digital economy and society phase 1: Digital Foundation. This plan has been revised and updated to DES Action Plan (3-year plan 2020–2022 revised edition 2021) which includes the following six objectives: 1) people have equal access to information and service via a cost-effective, universal, and efficient network 2) contribute to the economic value creation associated with the implementation of digital technology in business operations 3) people improve their quality of life by utilizing digital technology 4) the government has digitalized its processes and services to become a high-performing organization capable of operating successfully both domestically and internationally 5) develop workforce knowledge and abilities in digital technology that can be utilized to propel the economy and society and 6) all sectors have a high level of confidence in their abilities to leverage digital technologies.

Five important targets under strategy for digital infrastructure development in MDES Action Plan 5 Years (2018–2022) are as following: 1) fixed broadband is available in all villages (74,987 villages) 2) Thailand has become an ASEAN digital hub for connecting and exchanging information in the region 3) doubling the capacity of terrestrial cross-border connections with Cambodia, Myanmar, and Laos during the next three years 4) the indicator of technological infrastructure is ranked in the top 35 in the World Competitiveness Index and 5) the cost of fixed broadband services does not exceed 2.5% of GNI per capita.

5.2.3 (Draft) Digital Technology Infrastructure Action Plan Phase 1 (2022–2027)

The draft of Digital Technology Infrastructure Action Plan Phase 1 (2022–2027) is an action plan for developing the country's digital technology infrastructure in the next six years in accordance with The National Digital Economy and Society Development Plan and Policy from MDES (2018 – 2037). It related to targets for the growth of the digital economy and society in 2 phases which are phase 2: Digital Thailand I: Inclusion for the first year of operation, followed by phase 3: Digital Thailand II: Full Transformation for the next five years. It has three targets related to digital infrastructure development as follows:

1) Infrastructure Targets

- ◆ Fixed broadband speeds of at least 100 Mbps shall be available nationwide.
- ◆ All households have access to a fixed broadband speed of 1 Gbps for urban areas, economic zones, and public utility enterprises such as schools, sub-district hospitals, and local community learning centers.
- ◆ Increase the submarine cable capacity and terrestrial cross border link.

2) Connectivity Targets

- ◆ Fixed broadband penetration by households is more than 70% by 2022 and more than 80% by 2027.
- ◆ Fixed broadband service prices are not exceeded 1% of GNI per capita.

3) Competitiveness Targets

- ◆ The Network Readiness Index (NRI) will increase by at least in five ranks.
- ◆ Technological infrastructure indicator ranks in the top 35 in the World Competitiveness Ranking.

5.3 Regulations and Plans under Regulatory Agencies

The NBTC office is recognized as the primary driver of Thailand's telecommunication infrastructure development, allocating telecommunication resources and regulating Broadcasting and Telecommunications Services to maximize public benefit. To improve fixed broadband, a policy stimulus is critical for expanding coverage to all villages and populations while maintaining fair competition and affordable prices. The NBTC has introduced the Telecommunications Master Plan No. 2 (2019–2023), the Universal Service Obligation Plan No. 2 (2016–2021), and the Draft of Universal Service Obligation Plan No. 3 (2022–2026), which the NBTC is currently revising and authorizing.

5.3.1 Telecommunication Master Plans No. 2 (2019–2023)

The Telecommunications Master Plan No. 2 (2019–2023) focuses on allocating telecom-resources to meet demand and maximize efficiency. This master plan also prioritizes the expansion of basic telecommunications infrastructure, which enables people to access and benefit from telecom services. The policy includes spectrum licensing and telecom-infrastructure development to reduce digital divide gap. For developing telecommunications infrastructure, open access is being used to encourage any telecommunications operators to share networks in order to maximize network efficiency and provide customers with alternative options when selecting their services. Furthermore, the Last-Mile network was expanded to improve access in rural areas, enabling broadband service to be provided to all villages, schools, and sub-district health promotion Hospitals. However, the implementation of this master plan will provide significant challenges, especially in devising incentive mechanisms for telecom-operators to extend network coverage because investment costs are substantial and may not be worth the investment.

The telecommunication master plan is comprised of 6 strategies, which are as follows: 1) developing the Telecommunications industry and Promoting Free and Fair Competition: focus on expanding broadband coverage, effectively utilizing existing telecommunication infrastructure, and promoting access to services at affordable prices. 2) license and Regulation of Telecommunications and Radio communication: focus on improving management efficiency and monitoring compliance with license conditions. 3) efficient Telecommunications Resource Management: focus on the efficient use of spectrum and numbering in order to facilitate the development of digital technology 4) universal Basic Telecommunications and Social Services: focus on universal basic telecommunications services in both spatial and social dimensions; 5) consumer Protection in Telecommunications and Social and Public Benefits: focus on empowering consumers in the telecommunications industry and increasing awareness of telecom benefits 6) Economic and Social Support for Digital Development: focus on collaboration to facilitate the digital economy and social development policies.

5.3.2 The Universal Service Obligation Plan (USO) No. 2 (2016–2021)

The main objective of USO plan No. 2 is to expand broadband service coverage which includes investments in telecommunications infrastructure and the provision of high-speed internet service in all areas as well as to all demographic groups (the Village Level) through a collaboration with the government under “Upgrading Telecommunication Infrastructure Project to Drive the National Economy Project”. According to NBTC’s implementation, broadband service coverage was expanded to 19,652 villages, including 15,732 rural villages and 3,920 border villages, with connectivity speeds at 30/10 Mbps or 30/5 Mbps when connected via satellite system. Furthermore, under the same project, the Ministry of Digital Economy and Society expanded coverage to 24,700 villages (Net Pracharat’s project).

As a result of project, broadband service coverage in Thailand has been expanded to 44,352 villages, with connectivity rates of 30/10 Mbps. However, there are some villages that have been upgraded to 100/50 Mbps for 10,000 villages.

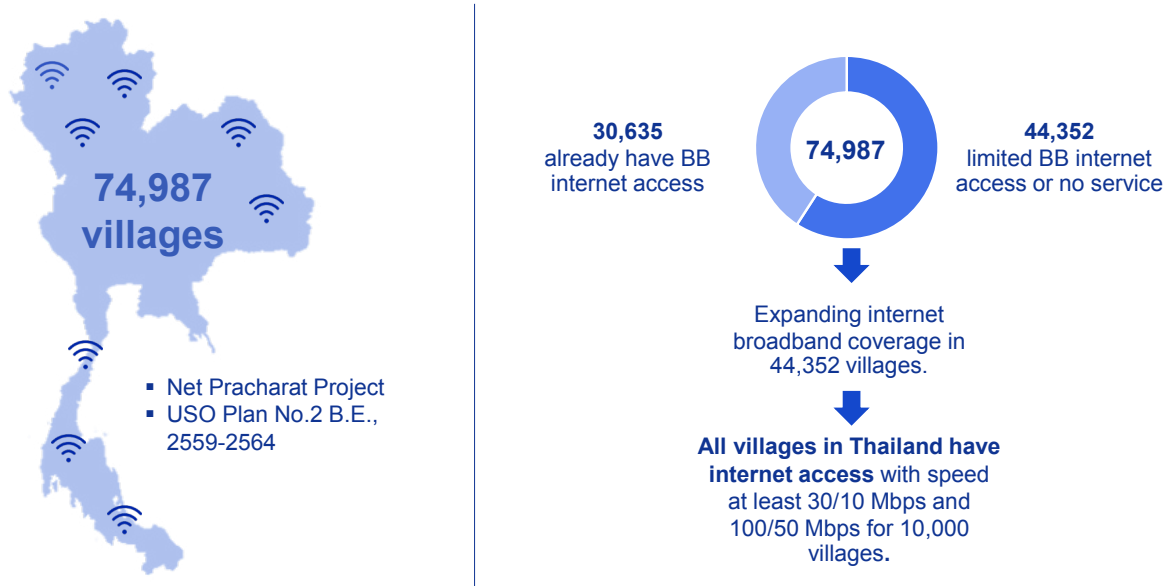


Figure 5-3: Upgrading Telecommunication Infrastructure Project to Drive The National Economy Project

5.3.3 (Draft) The Universal Service Obligation Plan No. 3 (2022–2026)

The USO Plan No. 3 (2022–2026) focuses on expanding the deployment of network and internet services under the “Upgrading Telecommunication Infrastructure Project to Drive the National Economy Project”, which have already been installed, to assist associated agencies in operating more efficiently and effectively. Additionally, it focuses on the development of ICT literacy for target groups in order to enable them to access and use telecommunications services, as well as the development of ICT awareness in order to assure security.

The Bureau of General Telecommunications and Social Services (USO Bureau) convened a meeting with 19 key relevant agencies to investigate the difficulties and inefficiencies of communications networks and propose solutions. According to the brainstorming, the operating framework are as follow: 1) expanding basic telecommunications service in spatial dimensions to cover all areas, including missing villages, schools, hospitals, public service agencies, and USO target groups such as the elderly, low-income individuals, farmers, disabled individuals, and public service agencies that lack telecommunications service. 2) utilizing the existing network and internet service, a result from USO Plan No.1 and No.2, to support government or public service agency operations. 3) improving a method for effectively providing USO services in response to the pandemic of COVID-19, which

necessitated prompt assistance. 4) developing ICT literacy and awareness. The NBTC divides the strategies for universal service duty into four strategies, as follows:

- ◆ Strategy 1 : USO services to support educational services.
- ◆ Strategy 2 : USO services to support medical service.
- ◆ Strategy 3 : USO services for the public purposes.
- ◆ Strategy 4 : Developing ICT knowledge and human resources.

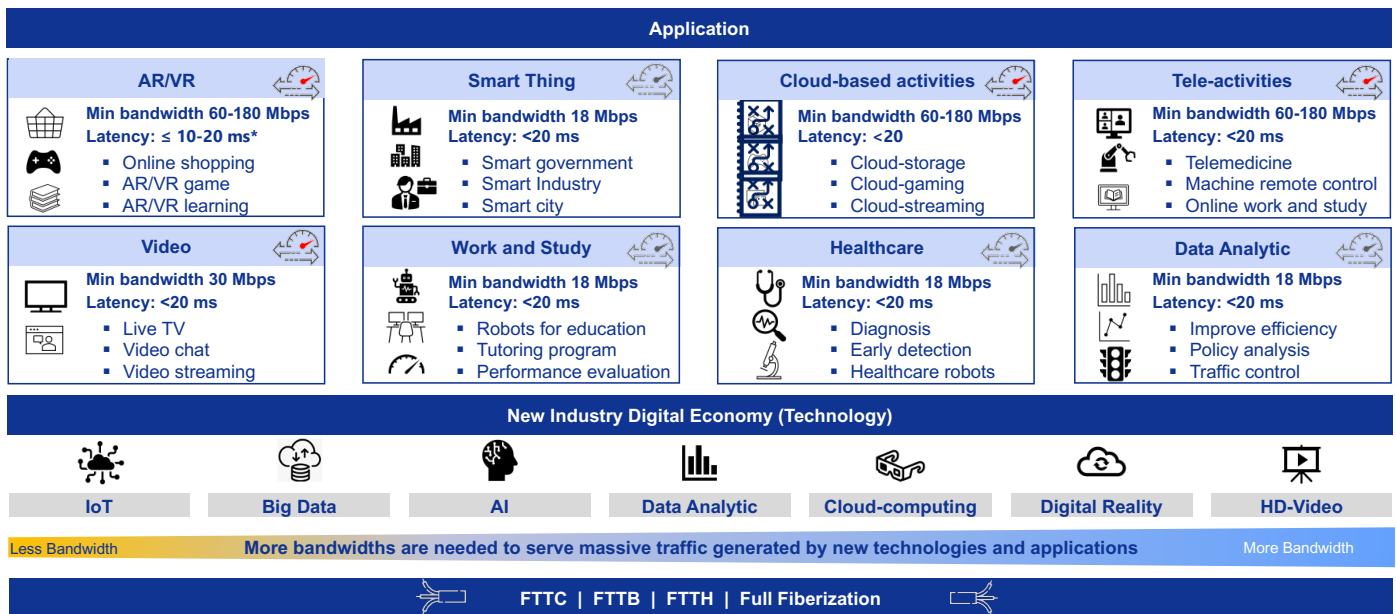
The targets and indicators are as follows: 1) provide basic telecommunications services to government agencies and non-profit organizations that support society at a minimum of 10,000 service points. 2) establish public internet centers at least 1,000 access points. 3) deliver at least three essential telecommunications services to USO target groups. 4) improve the ICT skills of at least 700,000 individuals.

5.4 The Importance of Broadband Infrastructure to Economic and Social Development

5.4.1 The Importance of Gigabit Broadband to Future Technology

Gigabit Broadband is designed to deliver internet services at up to 1 Gbps over fiber optic networks in a variety of ways, including connecting fiber optic cables to the control cabinet (FTTC: Fiber-to-The-Cabinet), connecting fiber optic cables to buildings (FTTB: Fiber-to-The-Building), and connecting fiber optic cables to individual households (FTTH: Fiber-to-The-Home). This connection can support high-speed data transmission due to its wider bandwidth. Therefore, it is important to provide a foundation for future technologies that require faster, larger connections, such as the following: 1) Internet of Things (IoT) is a network of devices equipped with sensors or embedded processors and are capable of recording, receiving, and transmitting data over the internet. 2) Big Data is a collection of large and complex data that can be further used for data analytic. 3) Artificial Intelligence (AI) refers to a system that performs deep

processing and is trained with mechanisms for learning and processing massive volumes of data. It can be utilized in a variety of ways based on the user's preferences. 4) Data analytic is the process of transforming and analyzing information from Big Data for modeling, forecasting, and adopting for other applications. 5) Cloud Computing is a service that enables the processing of both hardware and software, as well as data storage and online systems, via the internet. 6) Digital Reality is a computer-generated simulation of a virtual surround landscape that enables people to interact with the virtual environment using equipment like cameras, keyboards, microphones, and headphones. 7) High-definition video refers to the transmission of high-resolution audio and video signals. As a result of mentioned technologies, high-bandwidth applications such as smart cities, online education, cloud storage, and telemedicine medical service robots have been developed.



*Latency ≤10 ms for strong interaction and ≤20 ms for weak interaction

Figure 5-4: The Important of Giga Broadband to The Future Technologies






5.4.2 Applications

At the present, numerous applications based on future technologies are being developed for the market. All of these require increased bandwidth and lower data transmission latency in comparison to previous applications to ensure that users have an enjoyable and efficient experience with the application. The following are some examples of applications: 1) AR/VR applications, such as gaming and education, require a minimum of 60–180 Mbps and a latency of less than or equal to 10–20 milliseconds. 2) Video applications, such as HD video playback and video conferencing, require a minimum of 30 Mbps and a latency of less than 20 milliseconds. 3) Smart things, such as smart cities and intelligent industries, require a bandwidth of at least 18 Mbps and a latency of less than 20 milliseconds. 4) Learning and working, such as educational robots, analysis of learning plans through data processing, requires a bandwidth of at least 18 Mbps and a latency of less than 20 milliseconds. 5) Cloud computing activities, such as cloud gaming and cloud storage, requires at least 60–180 Mbps of bandwidth and a latency of less than 20 milliseconds. 6) Health and medical profession, such as disease analysis from data processing, medical robot, require a bandwidth of at least 18 Mbps and a latency of less than 20 milliseconds. 7) Remote activities, such as remote diagnosis, requires at least 60–180 Mbps of bandwidth and a latency of less than 20 milliseconds. 8) Data analytic, such as optimization, traffic light management, requires a bandwidth of at least 18 Mbps and a latency of less than 20 milliseconds. Notwithstanding, the great majority of applications for fiber optic networks are for fixed broadband. A single access point can connect multiple users, allowing for concurrent operation of multiple applications. As a result, bandwidth consumption may increase exponentially.



5.5 Thailand's Broadband Infrastructure Development Targets

From the national policies, Thailand Digital Economy and Society Development Plan (2018–2037) from MDES, MDES Action Plan (2018–2022) and ONDE Action Plan (2022–2027) have **seven key targets** related to the development of broadband infrastructure as follows:

	2020	2022	2025	2027
Infrastructure	Coverage  <ul style="list-style-type: none"> Cover 74,987 villages 	<ul style="list-style-type: none"> Fixed broadband cover all villages and countryside 	<ul style="list-style-type: none"> FBB cover every household for Zone A & B 	<ul style="list-style-type: none"> Cover every household
	Service Quality  <ul style="list-style-type: none"> Urban fixed broadband speed 191/151 Mbps Rural fixed broadband speed 30/10 – 100/50 Mbps 	<ul style="list-style-type: none"> All villages have fixed broadband speed > 100 Mbps 	<ul style="list-style-type: none"> Fixed broadband speed for urban and economic zones > 500 Mbps 	<ul style="list-style-type: none"> Fixed broadband speed for urban and economic zones > 1 Gbps
	International Connectivity  <ul style="list-style-type: none"> Submarine cable design capacity 153.01 Tbps Terrestrial cross border link 250 Gbps International internet Bandwidth 14.1 Tbps 	<ul style="list-style-type: none"> Submarine cable design capacity 437.01 Tbps (+ADC, SJC2) Terrestrial cross border link +140 Gbps 	<ul style="list-style-type: none"> Submarine cable design capacity (2023) 637.01 Tbps (+IAX) Terrestrial cross border link +1.2 Tbps (2022-2026) 	<ul style="list-style-type: none"> Submarine cable design capacity 1000 Tbps Terrestrial cross border link 1.59 Tbps approximately International internet Bandwidth 50 Tbps
Connection	Penetration  <ul style="list-style-type: none"> % FBB Penetration by HH is 51.5% % FTTH Penetration by HH is 30% 	<ul style="list-style-type: none"> % FBB penetration by HH > 70% % FTTH Penetration by HH is 50% 	<ul style="list-style-type: none"> % FBB penetration by HH > 75% % FTTH Penetration by HH is 70% 	<ul style="list-style-type: none"> % FBB penetration by HH > 80% % FTTH Penetration by HH is 75%
	Affordability <ul style="list-style-type: none"> Fixed broadband subscription rate is 2.83% of GNI per capita 	<ul style="list-style-type: none"> FBB subscription rate reduces to 2.5% of GNI per capita 	<ul style="list-style-type: none"> FBB subscription rate reduces to 1.8-2.0% of GNI per capita 	<ul style="list-style-type: none"> FBB subscription rate reduces to 1% of GNI per capita
Others	Digital economy <ul style="list-style-type: none"> Digital Economy Contribution to GDP : 17% 	<ul style="list-style-type: none"> Digital Economy Contribution to GDP : 20% 	<ul style="list-style-type: none"> Digital Economy Contribution to GDP : 22% 	<ul style="list-style-type: none"> Digital Economy Contribution to GDP : 25%
	World Index  <ul style="list-style-type: none"> WC (2021) Rank 37th NRI (2020) Rank 51st 	<ul style="list-style-type: none"> WC within Rank 35th 	<ul style="list-style-type: none"> WC (2025) within Rank 33th 	<ul style="list-style-type: none"> WC within Rank 30th NRI step up 5 rank within 5 years

Note: WC is IMD World Competiveness Ranking

ADC (Asia Direct Cable Consortium) is new submarine cable to connect Thailand to Asia Pacific Nation

Figure 5-5: Thailand's Broadband Infrastructure Development Targets

1) Fixed Broadband Coverage: Fixed broadband reached 74,987⁵⁸ villages in 2020, with the targets of reaching all villages by 2022, fiber optic broadband is planned to cover all households as well as in zone A and B by 2025. Ultimately, by 2027 the coverage to all households.

⁵⁸The village broadband internet project, under Upgrading Telecommunication Infrastructure Project to Drive the National Economy, GIS NBTC, 2017

2) Fixed Broadband Quality: Urban areas had a fixed broadband speed of 191/151⁵⁹ Mbps, while rural areas had an average fixed broadband speed of around 30/10 Mbps to 100/50⁶⁰ Mbps in 2020. By 2022, all villages will have access to fixed broadband at a speed of more than 100 Mbps. By 2025, Thailand should set additional targets for urban areas and economic zones to access to fixed broadband at a speed of more than 500 Mbps. The plan aims to boost fixed broadband speed to more than 1 Gbps by 2027, covering urban areas, economic zones, and public utility enterprises such as schools, sub-district hospitals, and local community learning centers.

3) International Connectivity: Thailand had a total of eight submarine cables in 2020, with a design capacity of 153.01⁶¹ Tbps. By 2022, it plans to increase submarine cable design capacity to 437.01 Tbps by connecting two more routes which are 140 Tbps for ASIA Direct Cable Consortium (ADC) and 144 Tbps for Southeast Asia-Japan 2 Consortium (SJC2). By 2023, the submarine cable design capacity will increase to 637.01 Tbps, by connecting one more route: 200 Tbps for India-Asia-Xpress (IAX). By 2027, the submarine cable design capacity will be increased to 1,000 Tbps.

In 2020, the capacity of terrestrial cross border link was 250⁶² Gbps. It aims to add 140 Gbps of terrestrial cross border links in 2022 followed by another 1.2 Tbps during 2023 – 2026. By 2027, the total capacity of terrestrial cross-border links will be 1.59 Tbps.

In 2020, the international internet bandwidth was 14.1⁶³ Tbps, and it will be increased to at least 50 Tbps by 2027.

4) Fixed Broadband Penetration: Thailand had a fixed broadband penetration rate of 51.5%⁶⁴ of households, or around 11.5⁶⁵ million fixed broadband subscribers. It aims to increase fixed broadband penetration by households to more than 70% by 2022 and to more than 75% by 2025. By 2027, fixed broadband penetration will reach more than 80% of households.

⁵⁹Speedtest, Ookla, 2020

⁶⁰The village broadband internet project, NBTC, 2020

⁶¹Telegeography, 2021

⁶²MDES Action Plan 3-years, MDES, 2020–2022

⁶³Internet Bandwidth, NECTEC, 2020

⁶⁴Thailand Telecom Industry, NBTC, 2020

⁶⁵Calculated from the number of households, NSO, 2020

In 2020, the fiber to the home (FTTH) penetration rate was 30% of households, or approximately 6.7 million fiber optic broadband subscribers. The FTTH penetration rate by households is expected to increase to 50%, 70%, and 75% by 2022, 2025, and 2027, respectively, with one FTTH port per household. Moreover, Fiber to The Room, or FTTR, may emerge in Thailand in the coming year. Around 10,000 households are expected to use the FTTR by 2022.



However, to support the forecasted growth in FTTH penetration, the optical transport network (OTN) should be increased from 0.3 nodes per 10,000 users to 1 node per 10,000 users in the next two years.

5) Fixed Broadband Service Price of GNI per capita: Thailand had a fixed broadband service price of 2.83%⁶⁶ of GNI per capita or around 544 THB per month, based on ARPU and the market share of fixed broadband service provider⁶⁷. Fixed broadband service prices will be reduced to 2.5% of GNI per capita by 2022, and it should be between 1.8% – 2% by 2025. By 2027, it will be reduced to 1% of GNI per capita.

6) Digital Economy Contribution to GDP: In 2017, Thailand had a digital economy value of 17%⁶⁸ of GDP. It aims to increase the digital economy to 20% of GDP by 2022 and should increase to 22% of GDP by 2025. By 2027, the digital economy must be worth at 25% of GDP.

7) World Indexes: Thailand is ranked 37th in the technological infrastructure indicator in the World Competitiveness Ranking 2021. It aims to improve its technological infrastructure ranking in the top 35 by 2020 and should be in the top 33 by 2025. By 2027, technological infrastructure will have to rank in the top 30.

⁶⁶Calculating from 1) Thailand GNI, World Bank, 2020 2) Telecom market, NBTC, 2020 3) Fixed broadband ARPU, annual report of each operator, 2020

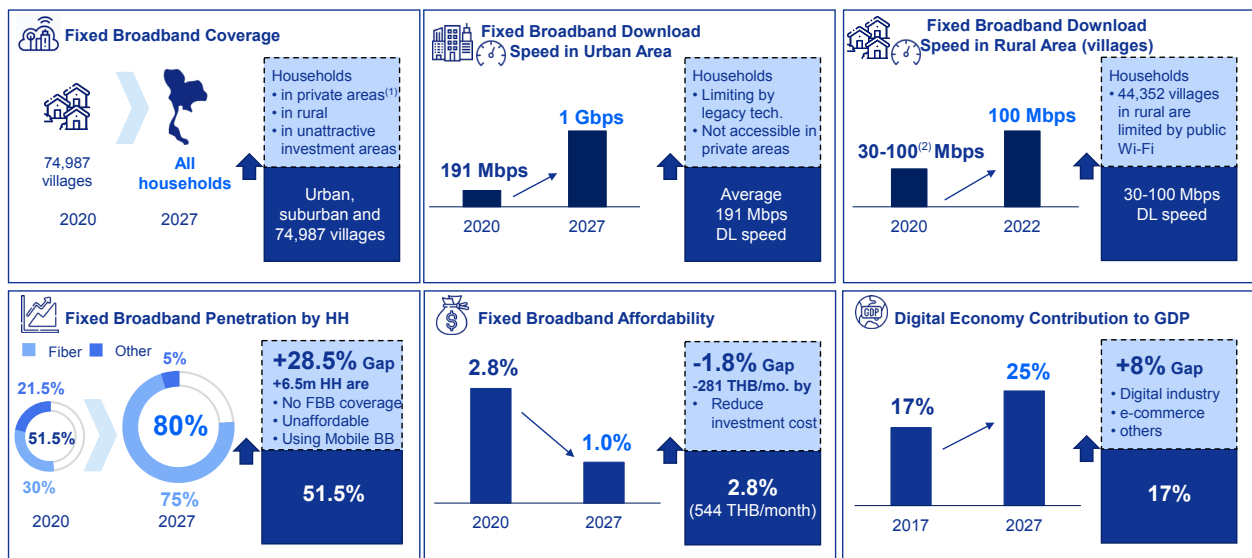
⁶⁷Calculating from 1) Telecom market, NBTC, 2020 2) Fixed broadband ARPU, annual report of each operator, 2020

⁶⁸Digital Ecosystem, BOI, 2020

In addition, Thailand was ranked 51st in Network Readiness Index (NRI) in 2020. It will improve the NRI ranking by at least five places and by 2027, or one place every year.

5.6 Gap Analysis for Giga Fiber Development for Target Achievement

From the topic 5.5, it can be indicated that there are **five main targets** and indicators for gigabit broadband: 1) fixed broadband coverage 2) fixed broadband quality 3) fixed broadband penetration 4) fixed broadband service price of GNI per capita and 5) digital economy contribution to GDP, which can analyze the gaps between current state and the development of gigabit broadband as follows:



Note: (1) Private areas are for example residential building, office building, housing estate, industrial estate etc.
 (2) "Community Public Wi-Fi" Project 10,000 Wi-Fi have speed 100/50 Mbps

Figure 5-6: Gap Analysis of Main Targets And Indicators in The Development of Gigabit Broadband in Thailand

1) Fixed Broadband Coverage: Thailand's fixed broadband coverage must be expanded to cover all households, private areas, particularly those in rural areas, and unattractive investment areas to achieve the target of providing fixed broadband to all households by 2027, based on the coverage of fixed broadband in 4,987⁶⁹ villages in 2020.

2) Fixed Broadband Quality: The urban areas, economic zones, and public utility enterprises such as schools, sub-district hospitals, and community learning centers that use copper cable must be switched to fiber optic to support the increasing speed of fixed broadband to 1 Gbps by 2027, up from 191⁷⁰ Mbps in 2020.

For 44,352 villages located in rural areas that covering remote (Zone C) and border (Zone C+) areas, the fiber optic network must be expanded to increase the speed of fixed broadband to 100 Mbps by 2022, up from 30 – 100⁷¹ Mbps in 2020.

3) Fixed Broadband Penetration: Thailand needs to increase fixed broadband penetration by 28.5% of households, or around 6.5⁷² million fixed broadband subscribers. To achieve the targets of increasing fixed broadband penetration to more than 80% of households by 2027, up from 51.5%⁷³ in 2020, the increment of subscribers shall come from the households that lack coverage/connectivity to fixed broadband, low-income households, and households that use only mobile broadband.

⁶⁹The village broadband internet project, under Upgrading Telecommunication Infrastructure Project to Drive the National Economy, GIS NBTC, 2017

⁷⁰Speedtest, Ookla, 2020

⁷¹The village broadband internet project (Net Pracharat), NBTC, 2017

⁷²Calculated from the number of households, NSO, 2020

⁷³Thai Telecom Industry Database, NBTC, 2020



However, fiber penetration is predicted to increase by 45%, or around 10 million households by 2027, since FTTH technology tends to grow more rapidly in the future and is an important technology of Thailand's development of fixed broadband. FTTH technology may eventually replace other wired technologies, which reduce utilization.

4) Fixed Broadband Service Price of GNI per capita: Fixed Broadband service price was 2.83% of GNI per capita, or around 544 THB per month in 2020, which is calculated from ARPU and the market share of fixed broadband service provider⁷⁴. Thailand's fixed broadband service price must be decreased by 1.8% of GNI per capita, or around 281 THB per month, or pay the amount of the monthly service cost of approximately 263 THB to achieve the targets of decreasing fixed broadband service prices to lower than 1% of GNI per capita by 2027.

5) Digital Economy Contribution to GDP: Thailand's digital economy must be accelerated by 8% by investment in digital, e-commerce, and other sectors that related to achieve the targets of increasing digital economy to 25% of GDP by 2027, up from 17%⁷⁵ in 2017.

⁷⁴Fixed Broadband Market Share, NBTC, 2020

⁷⁵Digital Ecosystem, BOI, 2020



5.7 Technologies Supporting Fiber Optic Broadband Development

Gigabit fiber can be implemented using technologies that facilitate the growth of fiber optic broadband development, such as GPON, IPv6, DWDM and Wi-Fi 6. The transition to such a technology will be based on market mechanisms designed to keep service providers competitive. Moreover, a Digitalized Quick ODN accelerates gigabit fiber installation to the end user (last-mile) and regulatory tools such as map-base systems for monitoring fiber-optic network extensions and the quality of internet service countrywide (Broadband Monitoring System) are described as in figure 5-7.

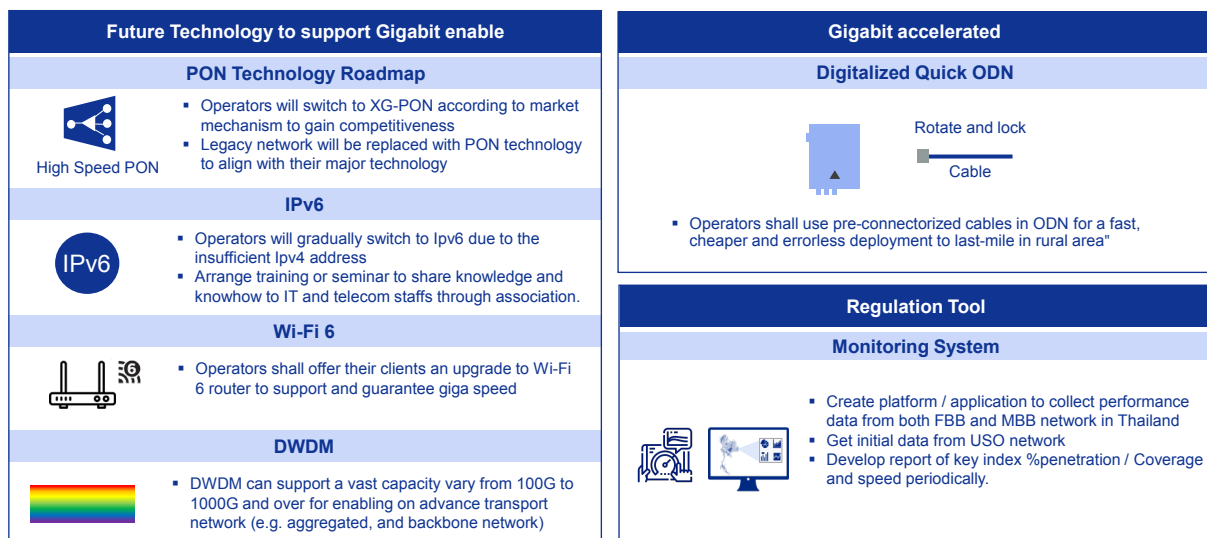


Figure 5-7: Overall of Giga Fiber Supported Technology

5.7.1 GPON Technology Roadmap

GPON (Gigabit Passive Optical Network) is a passive access network technology. It is a point-to-multipoint access network that gives users the ability to consolidate multiple services into a network over a single fiber optic transmission. The GPON consists of primary equipment, such as OLT, splitters and ONT devices. The ITU (International Telecommunication Union) has established development guidelines for the GPON technology, as illustrated in Figure 5-8. Countries such as the

United Kingdom, the Kingdom of Spain, the Italian Republic, the People’s Republic of China, the Hong Kong Special Administrative Region of the People’s Republic of China, and the Republic of Singapore are examples of countries that have begun to use XG(S) PON. Since 2015, several of them have been piloted as shown in figure 6–8. The evolution of GPON in Thailand can be divided into two paths by group of users: 1) Household users, for whom internet connectivity technology has evolved from Public Switched Telephone Network (PSTN) to FTTH or FTTB, which includes GPON and XG-PON access networks. 2) Enterprise users whose internet connection technology has evolved from a WAN (Wide Area Network) based on the X.25 protocol and PDH (Plesiochronous Digital Hierarchy) to an internet connection based on XG(S) PON, IP technology /DWDM 10G and 5G FWA (Fixed Wireless Access Network). However, XG(S)-PON technology tends to be used more among enterprise users. While GPON technology is likely to continue to be used by household users.

At the moment, some service providers are providing Gigabit connectivity via GPON technology. However, if service providers wish to deliver Gigabit connections or greater, they must migrate to XG-PON technology. In Thailand, only few service providers have begun testing the technology, and some providers are capable of delivering a symmetrical connection, which implies that download and upload speeds are equivalent.

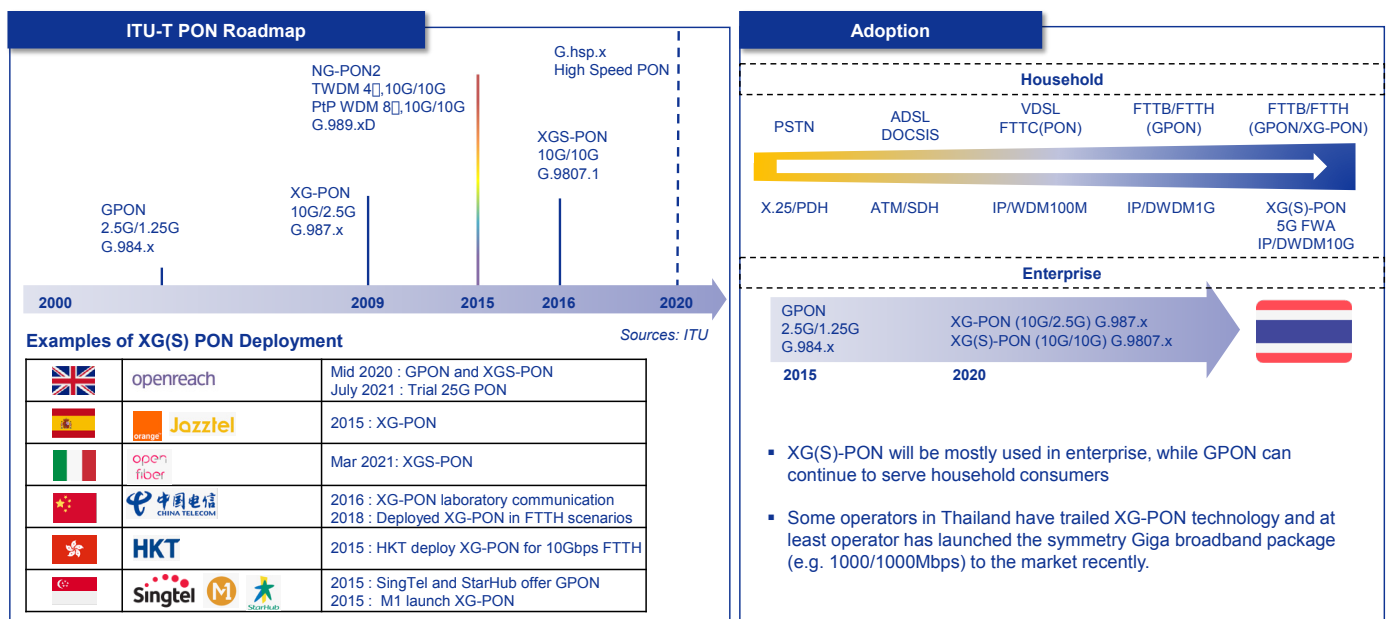


Figure 5-8: GPON Technology

5.7.2 IPv6

Nowadays, there is a surge in broadband usage and internet connections, necessitating the use of the internet and fiber optic networks to connect smart devices such as mobile phones, PCs, and, more recently, IoT devices. In 2019, IoT devices climbed by 23% over the previous year. However, smart devices must be identified and addressed in the network using Internet Protocol (IP), and IPv4 Internet Protocol addresses are limited and insufficient in the future to allow the identification of further smart devices. Service providers should migrate to IPv6, which supports a greater number of devices than IPv4. IPv6 is a 128-bit address, which is larger than IPv4's 32-bit address. IPv6 has a maximum address capacity of 7.9×10^{128} , which is equivalent to the number of devices it can support. Thailand has equipment capable of supporting IPv6 usage at a rate of 42.63%, which is greater than the global average. Many telecommunication operators are transitioning to use more IPv6 connections.

In this regard, a policy should be established to encourage and support the use of IPv6 connections. In 2027, the complete IPv6 transition is expected to be done. Thailand's Ministry of Information and Communications Technology (ICT) has a policy to promote IPv6, which is separated into two phases: The development strategy for the years B.E. 2013-2015 is divided into four areas: 1) Development of infrastructure 2) Development of services 3) Development of personnel 4) Raising awareness and encouraging the usage of IPv6; and the second phase of the strategy is the development phase, which will focus on creating targets to further the first phase's objectives. Figure 6-9 illustrates the details. However, service providers will switch to IPv6 connections as a marketing mechanism when IPv4 connections are no longer available.



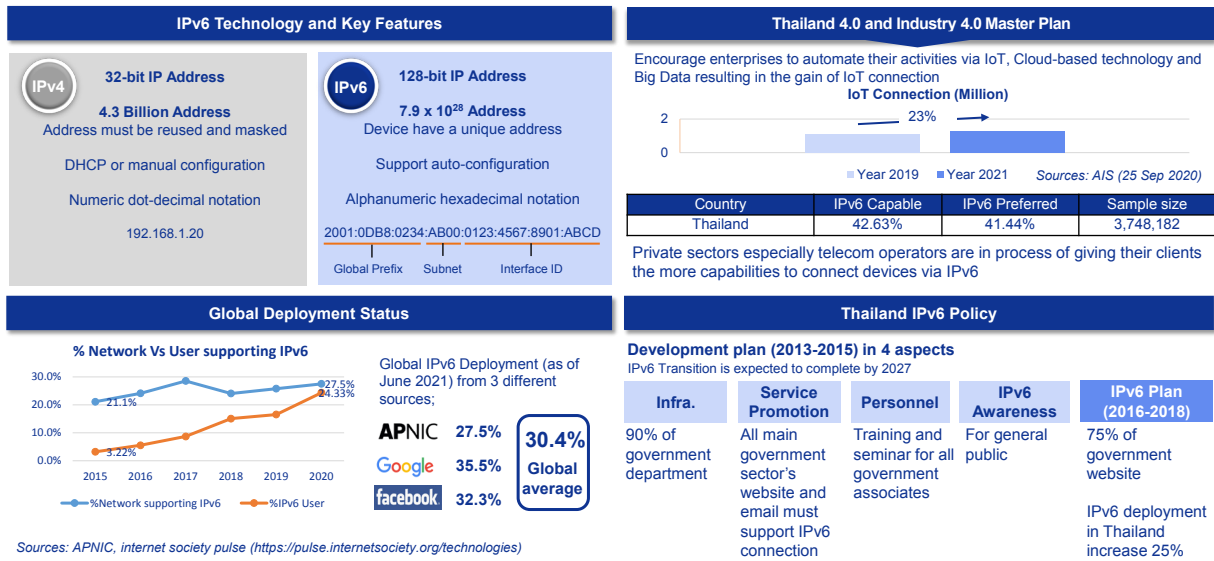


Figure 5-9: IPv6 Technology

5.7.3 Wi-Fi 6

Wi-Fi is a wireless network that communicates using radio waves. Wi-Fi 6 is the sixth generation of the Wi-Fi standard, which was established by the International Institute of Electrical and Electronics Engineers (IEEE). The standard IEEE 802.11ax enables data transmission at up to 9.6 Gbps with device engineering adjustments such as switching to 1024 QAM modulation, implementing OFDMA resource management, enabling MIMO transmission, and utilizing frequency reuse BSS. The following features are included with Wi-Fi 6: It performs significantly better in densely populated areas and at large population densities, at least four times better per user. This includes the ability to receive and transfer data up to 40% faster for a single user, as well as prolonging the battery life of the device. According to the foregoing, Wi-Fi 6 is critical in assisting in reducing congestion and increasing the efficiency of data transfer from the core network to end devices. Despite this, the economic value of \$3.3 trillion in 2020 is expected to grow to \$4.9 trillion by 2025.

In Thailand, Numerous service providers, including as AIS 3BB and TRUE, should offer Wi-Fi 6 router replacements together with a 1 Gbps internet package to their existing and new subscribers for the most efficient connection. Additionally, certain device vendors, such as Huawei, TP-Link, and Asus, have already begun selling routers that support Wi-Fi 6 connectivity. The industrial sector will be the first to adopt such technology, followed by the household.

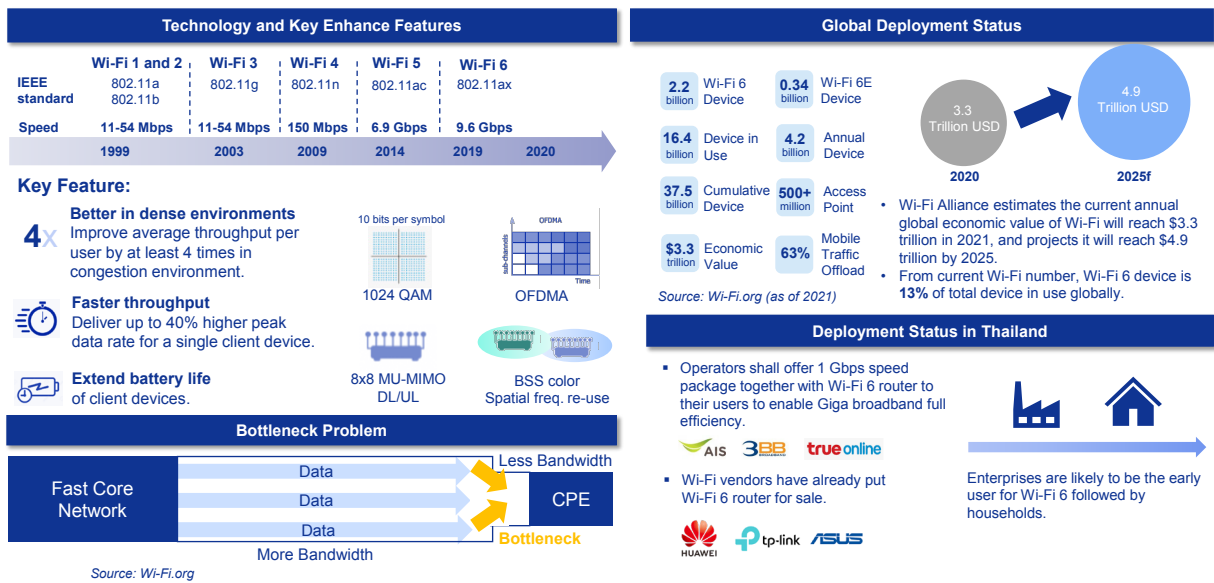


Figure 5-10: Wi-Fi 6 Technology

5.7.4 DWDM (Dense Wavelength-Division Multiplexing)

DWDM technology, or dense wavelength division multiplexing, is a method of transmitting data via a fiber-optic cable by combining signals of various wavelengths. The aforementioned technology expands the amount of bandwidth available for data transmission and reception. This improves the amount of data that can be sent at a single wavelength within a fiber-optic cable, enabling the efficient use of internet connections faster than 1 gigabit. The following are the advantages and benefits of the technology: 1) It is capable of transmitting massive amounts of data. Devices using DWDM technology offer multi-frequency aggregation and can transmit data 20 Tbsp. per system or more. 2) Fiber optic resources shall be saved by adopting this technology for data transmission. It takes only one pair of fiber optic cables to transmit and receive data, although additional data transfer is required. This is less than previous technologies such as SDH, which required an increasing number of fiber optic lines as the amount of data required increased. 3) Capacities can easily be increased without increasing the number of fiber optic cables by utilizing the existing optical line's available frequency. 4) The data can be transmitted over long distances using DWDM with an integrated amplifier. It enables the transmission of data over a great distance between 2,000–3,000 Km without the need for extra amplifiers. 5) The network's reliability will be increased. The majority of devices used in DWDM systems are photoelectric, or light-triggered devices, which

are extremely reliable and difficult to make errors in detecting light in fiber-optic cables. 6) It is capable of forming an all-optical network and connecting with other optical network devices such as OADM or optical redirection devices. This can help reduce work-related errors and network costs.

At current, DWDM devices are usually adopted by aggregating wavelength for example 80 wavelengths 128 wavelengths 160 wavelengths and supporting 100 Gbps to 1000 Gbps or more per wavelength. For Thailand, DWDM has been employed in core network for the last decade. The telecommunications operator has enhanced the device’s capabilities to enable aggregation of up to 120 wavelengths, with each wavelengths supporting data transfer rates of up to 200 Gbps which can be expanded capability in the future to support the expansion of the core network and effectively enable gigabit broadband services.

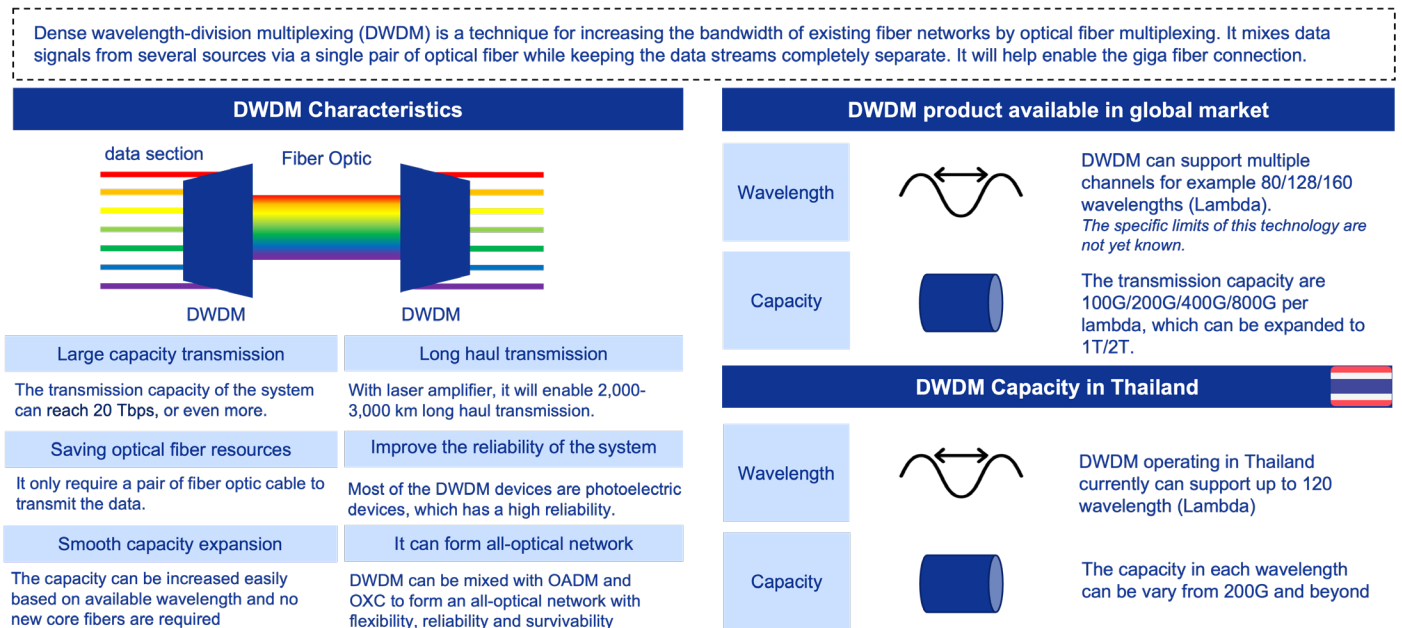


Figure 5-II: DWDM Technology



5.7.5 DQ-ODN

Digitalized Quick ODN, details are shown in Figure 5-12. It can be classified into 2 types: 1) Pre-connection: to pre-connectorized the equipment in the ODN network from the factory. This eliminates the need for specialists to install the equipment. 2) Digital labels and ODN management systems: to reduce errors in the equipment management. This technology enables the rapid connection and installation of such equipment, resulting in cost savings due to the needlessness of an expert or those who require training in the installation process, as well as a reduction in connection and installation errors. This speeds the connection to end users and saves more on the cost of network installation by focusing on the last-mile network in rural areas and the fiber pre-deployment in the building.

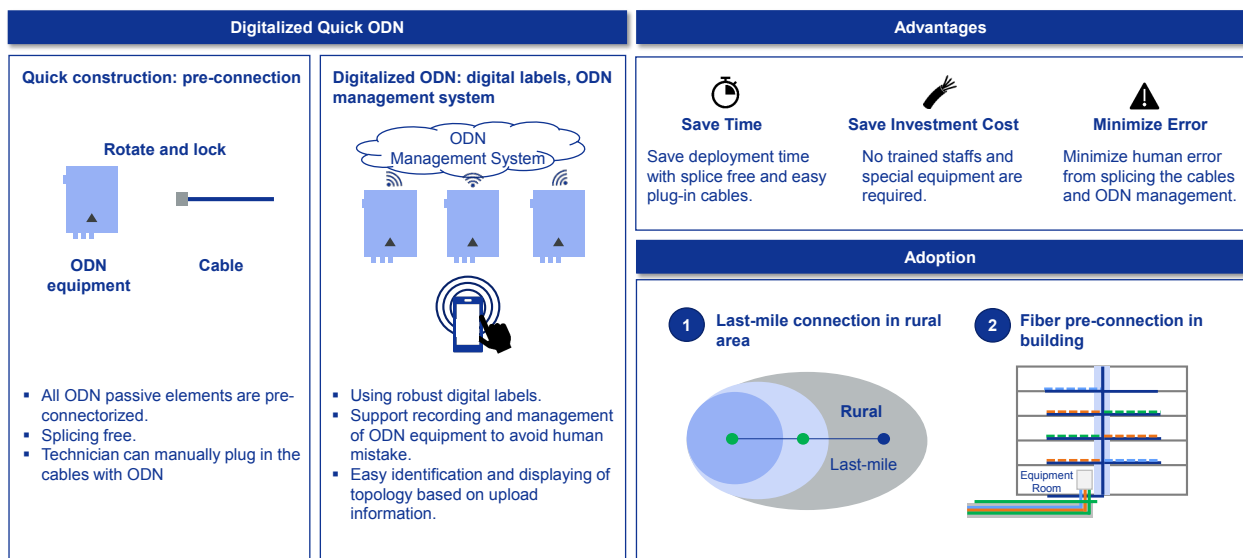


Figure 5-12: Digitalized Quick ODN

5.7.6 Regulation Tools

The map-based system that tracks the expansion of the fiber optic network and the quality of broadband internet across the country can be used as a regulation tool (Broadband Monitoring System) monitor and track the use and installation of fiber optic networks as a tool to assist with governance regulation. It is divided into the following three sections: 1) a system for monitoring the development of the fiber optic network, both in terms of installation expansion and service quality, in the form of a map, consisting of databases imported from NBTC, such as the optical

network database and the USO network database, as well as external databases, such as service provider databases; 2) channels or applications for collecting usage data from end users, including fixed broadband and mobile broadband internet, in all cities and locations such as schools, hospitals, government agencies, etc. 3) Creating progress reports that compare the fiber optic network's development results to the targets, including comparisons to global indicators. The report's details, such as the percentage of broadband internet access, percentage of fiber optic network coverage, and speed, should be updated on an annual or quarterly basis.

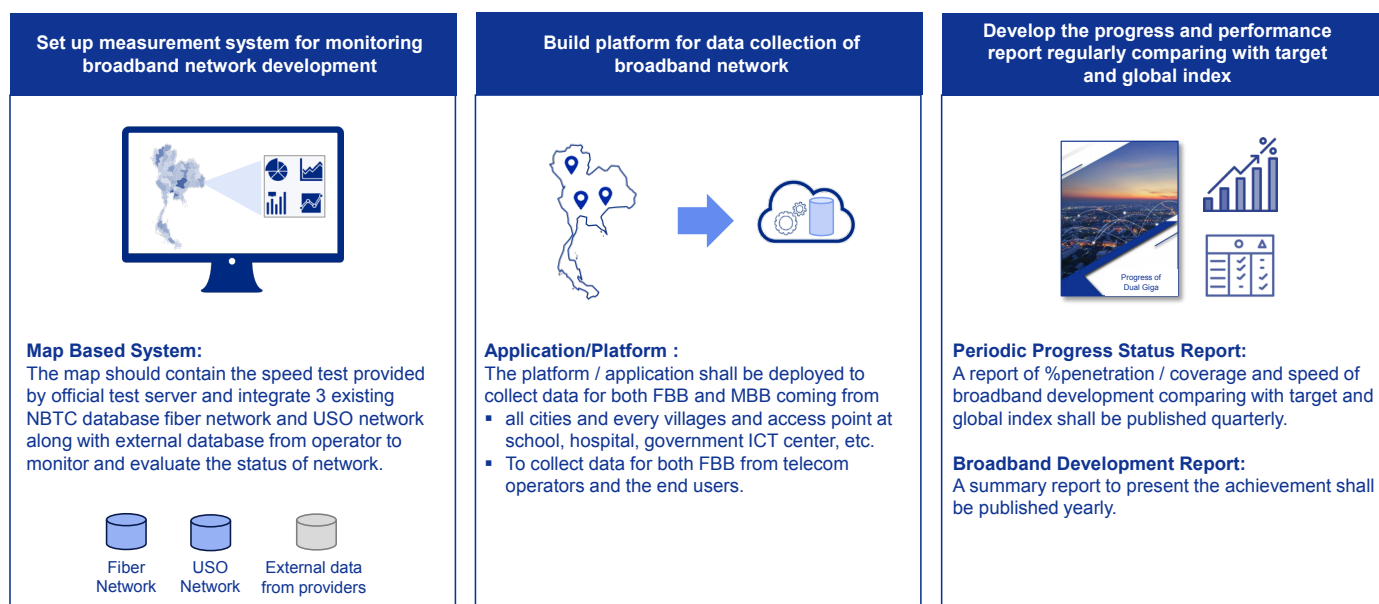


Figure 5-13: Regulation Tools



5.8 Guideline for The Development of Policy and Governance Goals

The Telecommunications Master Plan No. 2 (2019-2023), the Universal Service Obligation Plan No. 2, and the Universal Service Obligation Plan No. 3 are the guideline for the NBTC’s telecom regulations which are intended to support the development of comprehensive telecommunications infrastructures. Open access is one of the regulatory mechanisms stated in the master plan to encourage operators to open their networks for other operators to access resulting in a more efficient network utilization and provides end users with alternative options. Another important policy framework is developing of last-mile network, providing basic telecommunication services in remote areas and expanding the network cover all villages. Those policy frameworks, Gap Analysis, and technical study will be the guidelines to develop the policy and regulation recommendations in order to achieve the development of Giga broadband target. It can be summarized as the following picture in Figure 5-14.







Fixed Broadband Target 2027	How to Close the Gap	Government Policy and Regulation			
		Infra-sharing	Fiber Pre-deploy	USO Funding	Tools
 FBB Coverage All Households	<ul style="list-style-type: none"> Reduce investment cost Reduce investment time Remove barrier for accessing private areas 	●		●	
 FBB DL Speed in Urban Area 1 Gbps	<ul style="list-style-type: none"> Replace legacy in private area 	●	●		Infrastructure Atlas
 FBB DL Speed in Rural Area >100 Mbps	<ul style="list-style-type: none"> Connect with FTTH Increase capacity 			●	BB Monitoring
 FBB Penetration by HH 80%	<ul style="list-style-type: none"> Increase coverage in urban area Increase coverage in rural area Increase usage in rural area 	●	●	●	BB Monitoring
 Fixed Broadband Affordability 1% of GNI	<ul style="list-style-type: none"> Reduce investment cost Subsidy in rural area 	●		●	
 Digital Economy Contribution to GDP 25%	<ul style="list-style-type: none"> Increase investment & consumption Increase digital productivities 	Build the broadband infrastructure and ecosystem to support the digital industry and digital productivities			

Figure 5-14: Guideline for Development of Policy and Governance Goals

Coverage Target: In order to expand internet coverage to every national household as a target, redundant infrastructure costs and installation time must be reduced. As most of the network's costs come from deploying of infrastructure, connecting last-mile network, and installing network in private areas (e.g., residential buildings, office building, housing estate, and industrial estates, etc.). Therefore, the transparent infrastructure sharing shall be promoted and regulated including both open access and price regulation. Open access shall apply to passive telecommunications infrastructure such as electrical poles, underground ducts, and pre-deployed fiber cables in private areas. For remote areas, the existing network under "Upgrading Thailand's Telecom Infrastructure Project to Drive the National Economy" should be expanded by connecting last mile to individual household using FTTH technology.

Speed Target: The low average broadband speeds in major cities are due to the incapacity of copper and cable technologies to support fiber optic-based comprehensive telecom systems. As a result, the legacy technologies should be replaced by fiber-based technologies, particularly in private areas. For private areas, the fiber optic cables shall be pre-installed and open for other fixed broadband operators to access by requesting via map-based infrastructure sharing support system (Infrastructure Atlas System). For rural areas, the current speed should be increased to higher than 100 Mbps, by retrofitting the network configuration or upgrading the GPON technology in accordance with the ITU's roadmap. In addition, a broadband monitoring system should be implemented to track the network's expansion and quality.

Penetration Target: for urban areas, accelerating network expansion for coverage through infrastructure sharing, especially pre-deployed fiber cables, may result in a rapid increase in penetration rate. For rural areas, accelerating network expansion for coverage and encouraging local residents to use and adopt internet-based applications, may result in a rise in the number of users and penetration rate in non-municipal areas.

Pricing Target: to reach the target in lowering fixed broadband prices, fixed broadband operators consider cutting costs by sharing infrastructure. While low-income customers in rural areas, may require a subsidized support in order to gain access to the internet service at a reduced rate.

Digital Economy Target Issues: to accelerate economic growth by increasing the contribution of digital technology to GDP, it is required to raise investment and expenditure in the digital economy, as well as productivity growth in the digital industry.

Besides the above recommendations, technology is an important factor in achieving gigabit broadband adoption. The technologies are as follow:

- ◆ XG-PON Technology: Although internet service providers already use GPON technology to deliver gigabit broadband services, this might not be sufficient as the number of users growing. For more capabilities to boost speed, fixed broadband operators should upgrade their technology to XG-PON in compliance with the ITU's roadmap. It is not only should XG-PON technology be used to replace GPON, but also legacy technologies such as copper and coaxial cables.
- ◆ Transition to IPv6: Extending connectivity capabilities in order to support exponentially expanding device connections that surpass the IPv4-based IP address limit. Because IPv6 connections can support a significantly greater number of devices than IPv4 connections, service providers should implement an IPv6 transition strategy to mitigate the impact of IP address.
- ◆ Wi-Fi 6: It will be capable of transmitting data at a higher rate than Wi-Fi 5, thereby enabling gigabit connections to end devices.
- ◆ Digitalized Quick ODN: DQ ODN can reduce fiber optic networks to end users in last-mile connections by implementing pre-connectorized ODN (Optical Distribution Network) devices that eliminate the requirement for on-site splicing. Additionally, the ODN management system is also included, which makes it easier to record complex ODN data.
- ◆ Policy and regulation innovations: it is critical to ease the massive deployment of fiber optic cables for example, the Infrastructure Atlas system, which facilitates infrastructure sharing. Secondly, the Broadband Monitoring System, which monitors fiber optic network expansion and the quality of broadband internet service nationwide)

6 Infrastructure Sharing

Infrastructure sharing reduces the cost and time required to install and operate a telecommunications network, resulting in the greatest benefit to users in terms of service quality and price. Therefore, this policy is generally adopted in the development of telecommunication networks under the regulation of the infrastructure sharing.

6.1 Current Infrastructure Sharing Issues

Presently, telecommunications operators that provide broadband internet service have access to other operators' passive infrastructure (e.g., poles and ducts) and telecommunications networks (e.g., fiber optic networks and access networks). Under NBTC regulations, entities that have technical and commercial agreements to use the service or to provide services via the telecommunications network are permitted to do so. Regardless of Thailand's telecom market conditions, such services are regulated, there are still issues that can be considered to optimize infrastructure sharing in order to support the development of broadband internet. Expansion of telecommunications infrastructure alongside other utility infrastructure, determining the rate of compensation for underground duct usage, and allowing other operators equitable access to access networks in private areas are examples. This will be covered in more depth in the following sections.



6.1.1 Underground Duct Compensation

The NBTC has developed a plan for undergrounding communication cables in 2021 in collaboration with the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA), Bangkok Metropolitan Administration (BMA), the Royal Thai Police, the Telecommunications Association of Thailand under Royal Patronage, and telecommunication operators. The plan will organize communication cables and migrate to the underground duct, resulting in a picturesque landscape and increased public safety. Additionally, it contributes to infrastructure sharing, which enables the telecommunications industry to grow in the future.

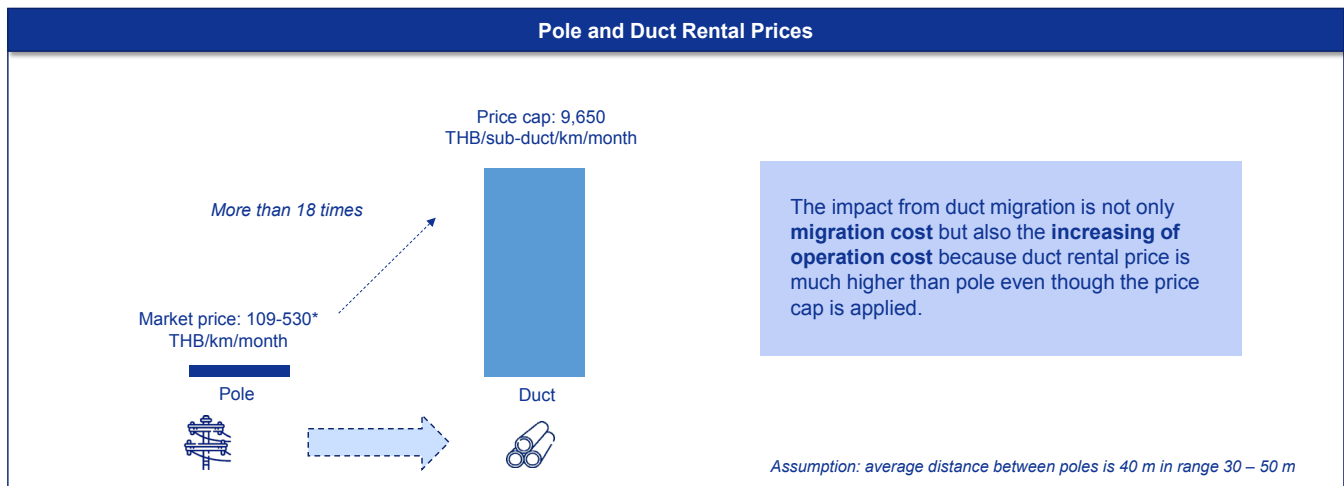


Figure 6-1: The Comparison Of Duct and Pole Compensation Rate

Although switching from laying fiber-optic cables on electricity poles to underground ducts can reduce signal interruption problems and maintenance costs for operators, such changes affect the cost of installing underground communication lines and the cost of renting underground duct. The duct rental rate is higher than the pole rental rate, increasing from 190–530 THB per kilometer to 5,314–9,650 THB/sub-duct/km/month. The maximum monthly rental rate was set at 9,650 THB. The maximum rental fee for underground conduits has been temporarily approved at 9,650 THB/sub-duct/km/month⁷⁶ including VAT, for a total of 10,325.5 THB, by resolution of the NBTC meeting No. 4/2020 on February 26, 2020. The expense of leasing the underground duct constitutes a long-term burden for telecommunications operators.

⁷⁶Notification of the NBTC on The Highest Rate of Compensation for Communication Ducts Usage

6.1.2 Fiber-optic Network in Private Area

At present, telecommunications operators are implementing infrastructure sharing in accordance with the NBTC notification: "Telecommunication access and interconnection" B.E. 2556. The notification is intended for operators who have been granted access to telecommunications networks pursuant to a technical and commercial agreement in order to use the network or provide a service via the network. Additionally, it refers to fiber-optic access networks established in private areas such as buildings, offices, housing estates, and industrial estates as the Access Network in Private Area. The area's SMP operator is likely to be the first operator to partner with the landlord or developer of the properties to establish a fiber-optic network. The SMP would propose a high rental rate and an unfair service in order to deprive other operators, rendering them uncompetitive and impeding the development and improvement of fixed broadband internet in private areas.

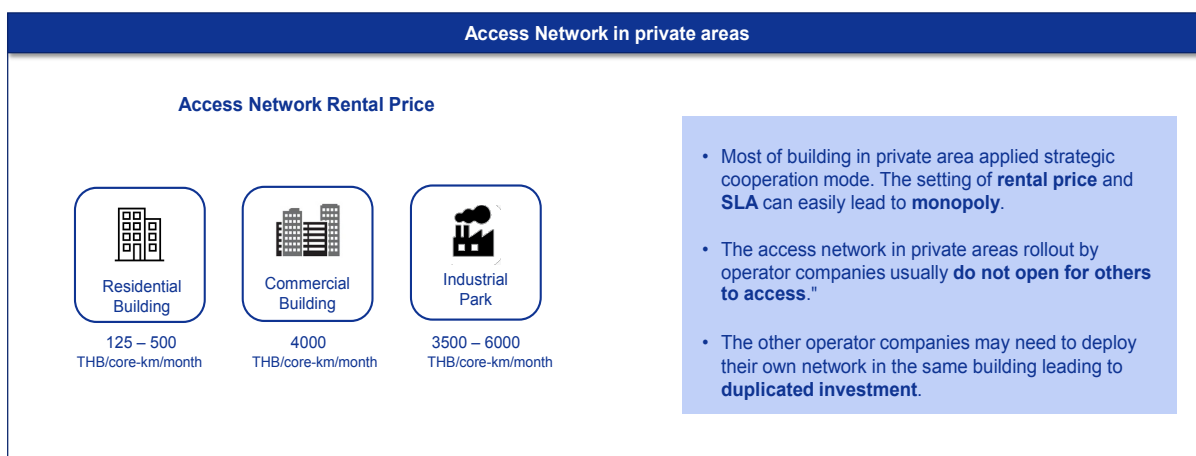


Figure 6-2: The Issue of Accessing Fiber-Optic Network in Private Areas

For a telecommunications network's rental fee is defined by the area's structure. Rental fees for home telecommunications networks range between 125 and 500 THB/core-kilometer on a monthly basis. Also, commercial buildings are charged at 4,000 THB/core-kilometer/month, whereas industrial estates are charged at 3,500–6,000 THB/core-kilometer/month. There are two types of telecommunications operators who build fiber-optic networks in private areas: network operators (who provide only the network) and fixed broadband providers (who provide both network and internet service). Both groups have to submit Reference Access offer (RAO) to NBTC. The RAO shall include the standard calculation and demonstrating the calculation for the rental rate, as well as

details of service quality, and conditions relating to confidentiality and information disclosure in accordance with the NBTC's notification on "Telecommunication access and interconnection" B.E. 2556. In practical, fixed broadband operators who provide internet service and installing telecommunications networks in private areas prohibit other operators from using their network. On the other hand, other operators lack confidence in their quality of services, resulting in investment duplication and service delays.

6.2 International Best Practices for Broadband Infrastructure Sharing

6.2.1 International Best Practice of Telecommunication Infrastructure and Utility Infrastructure Installation

The majority of the cost of investing in telecommunications infrastructure, particularly direct bury fiber optic cables and duct installation, is borne by construction or civil work. In the People's Republic of China, it has been proved that concurrently establishing telecommunications infrastructure alongside other infrastructure construction can lower construction costs by 30%. The telecommunication infrastructure that can be installed with other infrastructures is classified into three layers: 1) The core network (Backbone Layer) is the installation of a telecommunication network between cities parallel to the highway or railway. 2) The Aggregation Layer is the network infrastructure that connects a city's multiple distribution points and its main network. As a result, it can be integrated into the city's basic utilities, such as sewers, water pipelines, and underground electrical conduits. 3) Access network is a network that is deployed to end users. It can be constructed with basic utilities to enable access to households or offices, including the installation of a fiber optic network within the building to connect fiber to users in each residential unit concurrently with building development.

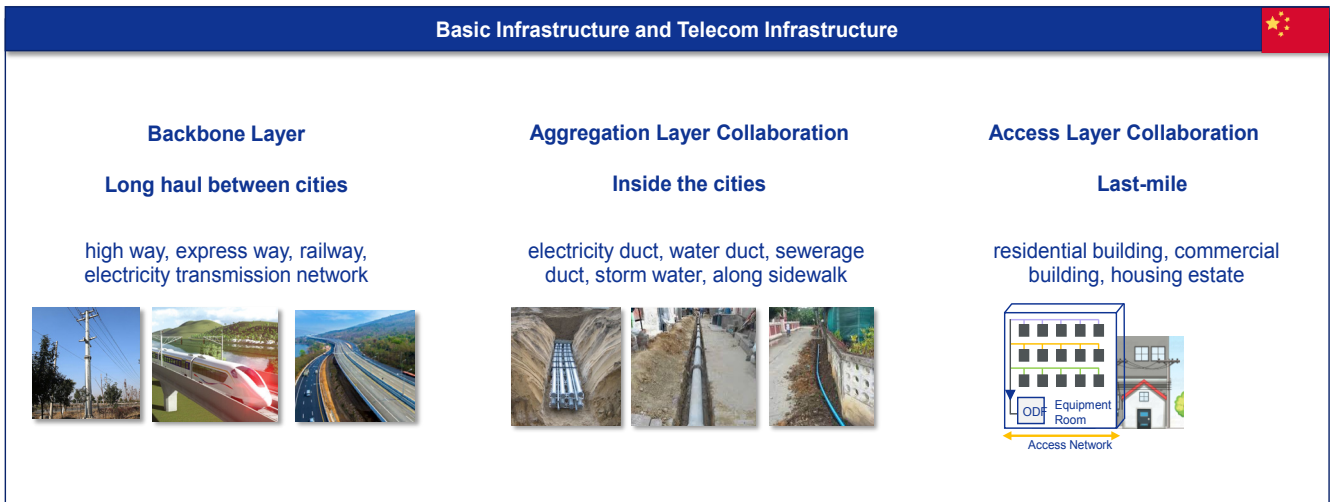


Figure 6-3: The Installation of Telecommunication Infrastructure with Other Infrastructures

In Germany, construction expenses are considerable high, accounting for around 80% of total costs, necessitating collaboration in the development of infrastructure. The cost-cutting policy is aimed at streamlining the planning and execution of civil works. The objective is to increase the efficiency with which telecommunications network infrastructure is developed. As a result, existing utility infrastructure such as water pipes, light pipes, lightning arresters, towers, and antennas shall be integrated into telecommunications infrastructure to the extent possible.

The telecommunications regulator works as an intermediary in coordinating infrastructure installation and expansion information with other infrastructure authorities. The online database maintained by the telecommunications regulator will collect notifications from other infrastructure authorities. Simultaneously, telecommunications operators can access this database. As a result, increased coordination with municipal infrastructure authorities is anticipated.



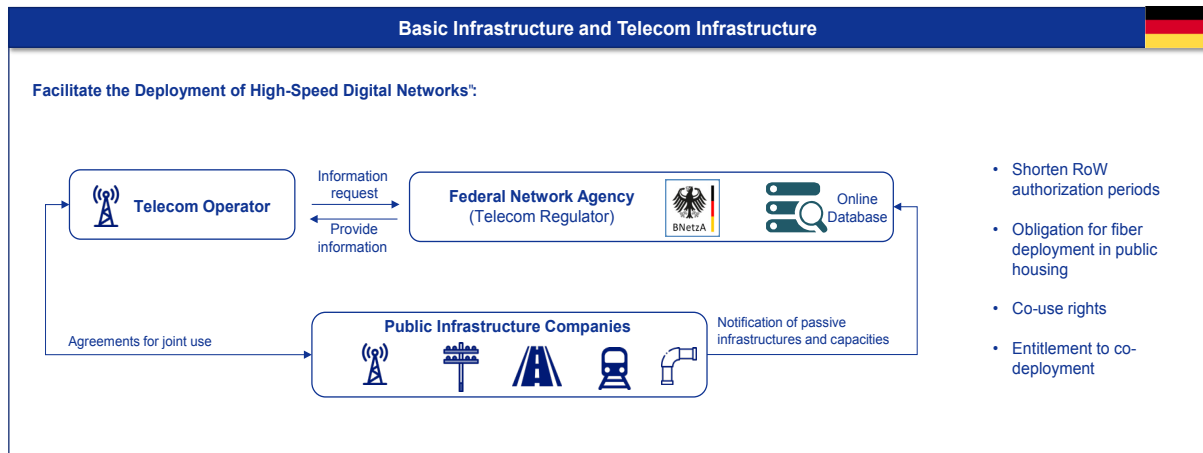


Figure 6-4: Online Notification of Installation and Expansion of Basic Services

Not only cost savings are realized as a result of this collaboration throughout the construction process, but the approval process can be also speeds up by combining the rights of way. Additionally, it might speed up the approval process by merging the rights. Additionally, it may permit fiber optic cable construction in public areas in conjunction with other services, lessening the impact on local residents.

6.2.2 Infrastructure Sharing in the United Kingdom (UK)

In the United Kingdom, most telecommunications lines are established to connect the operators to the end users. The wirelines were were operated and maintained by Openreach, a subsidiary of the BT group of companies. Other operators will be able to purchase wholesale broadband services from Openreach (e.g., BT, Sky and Talktalk). Due to Openreach's enormous network of ducts and poles, telecommunications regulators, ofcom, aim to expedite the expansion of broadband internet services by other providers. As a result, Openreach has been required to offer competitors access to its ducts and poles since 2010. However, only a small number of applicants apply for the service in the time-consuming and traditional manner. The approval process is multi-staged. As a result of this collaboration, the regulator works with Openreach and its stakeholders to improve the access process.

In 2016, infrastructure access and infrastructure sharing regulation were introduced as well as other infrastructure, such as gas pipes, electricity and water supply. This is referred to as Access to Ducts and Poles (DPA). The few applications that apply to Openreach's network may be the result of an ineffective DPA process, and Openreach's data for ducts and poles may be inaccurate or lack information about their conditions, such as not being located in the specified location, being damaged, or being unable to support additional fiber optic cables. These impediments prevent all operators (including BT) from using Openreach's ducts and poles, hence limiting the expansion of fixed broadband networks.

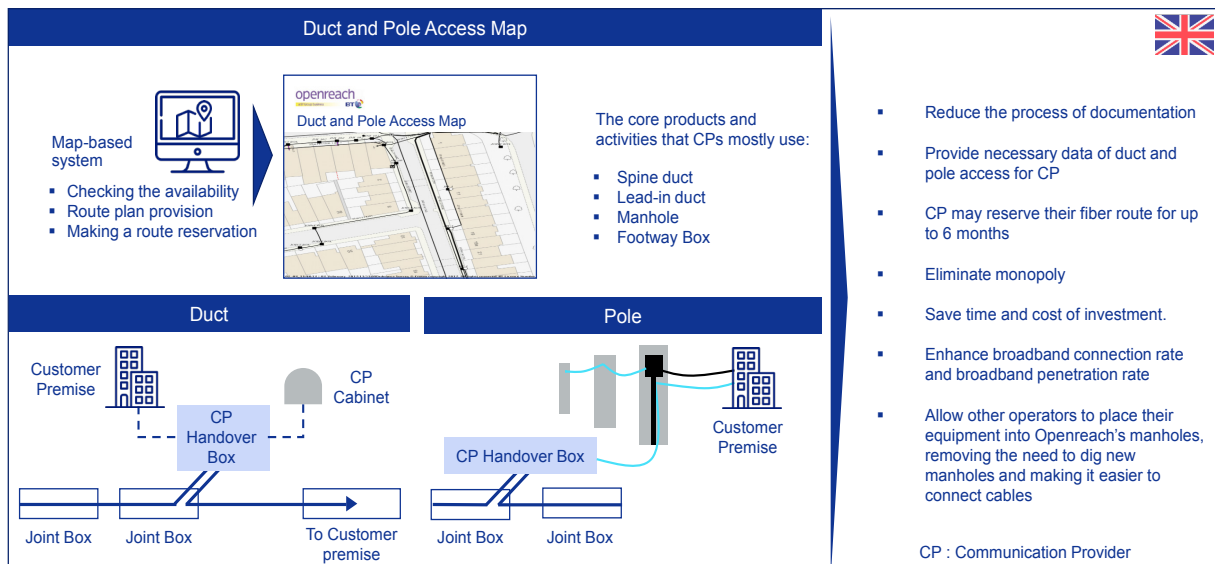


Figure 6-5: Passive Infrastructure Sharing with Map-Base Supporting System

ofcom is attempting to persuade Openreach to continue opening access for infrastructure sharing, but the approval process needs to be simplified to make it more accessible to other operators, including the development of a map-based system and an online tool to provide applicants with access to Openreach poles and ducts data. In March 2017, the system was implemented.



6.2.3 The Open Access Model in Singapore

Singapore first launched its efforts to develop broadband internet services in 2009. The national broadband network has been installed, enabling open access and infrastructure sharing via the Structure Separation model, with the goal of avoiding duplication of investment, eliminating access bottlenecks to telecommunication networks and infrastructure, and encouraging small operators to compete in the broadband internet service market through commercial agreements.

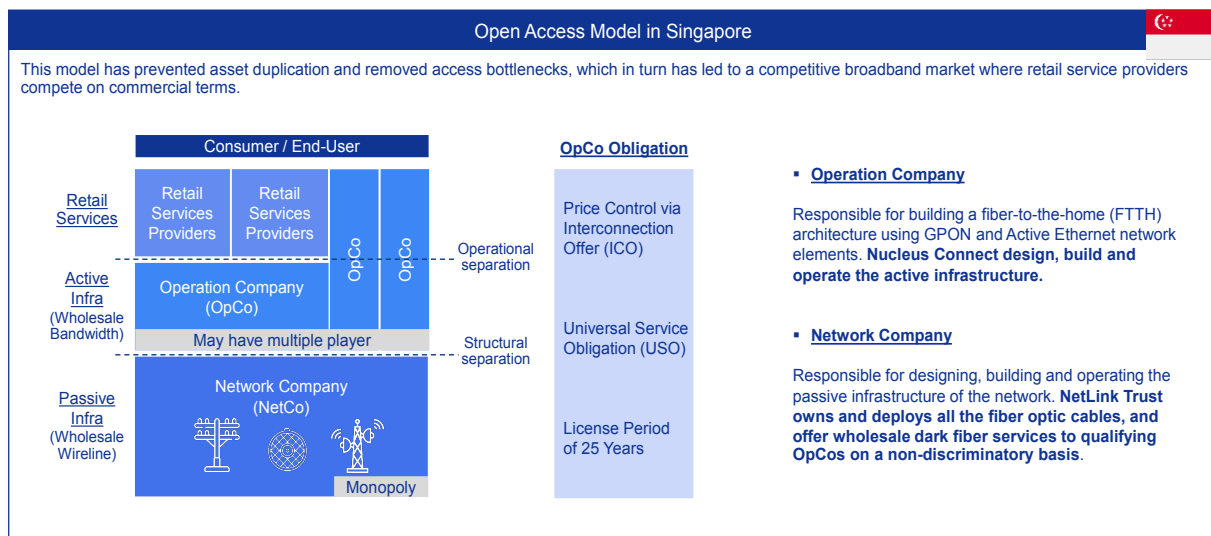


Figure 6-6: Open Access and Structure Separation Infrastructure Sharing

Separation of infrastructural structures can be divided into two types: 1) Passive infrastructure, which is operated by a network company. The network company constructs and installs passive infrastructure or dark fiber in order to enable operation company to access the network. 2) Active infrastructure which is operated by an operation company who connects the fiber optic networks to residential households via FTTH and GPON technology. The operation company may offer broadband services directly or through a retail service provider.

6.3 Recommendations to Regulate the Infrastructure Sharing

to address the issue of underground duct rental rates, which are a long-term commitment, and issue of fiber optic network access in private areas, including supporting the development of fiber broadband services, it is required to increase infrastructure sharing efficiency. As a result, greater consideration should be given to the regulation of infrastructure sharing. Moreover, the system should be built to facilitate the infrastructure's information and process exchange.

Provision of utility infrastructure and expansion of telecommunications infrastructure should be collaborative endeavors.

Because supplying basic utilities and expanding telecommunications infrastructure should occur concurrently in order to minimize construction costs and impact on people's daily life during the construction development period. An information center for fundamental infrastructure project plans should be established to promote collaborative planning between infrastructure authorities and telecommunications operators in planning infrastructure expansion and common telecommunications collaboratively.

Review of the regulation governing on underground ducts rental rates by using reference rate

The underground communication cable project effectively mandates that operators install fiber optic cables in subsurface ducts. Additionally, there is the cost of duct rental over time, which is substantially more expensive than pole leasing. To facilitate future fiber optic network expansion via underground duct migration and additional duct migration projects, the price regulation should be reconsidered. As a result, regulation of underground duct rental rates should be reconsidered in order to progress from a maximum rental rate to a reference rate. The reference rate must be computed using proper calculation standards at a reasonable cost, as telecommunications operators are unable to pick which route of the underground system is served by a single duct supplier. Additionally, to ease

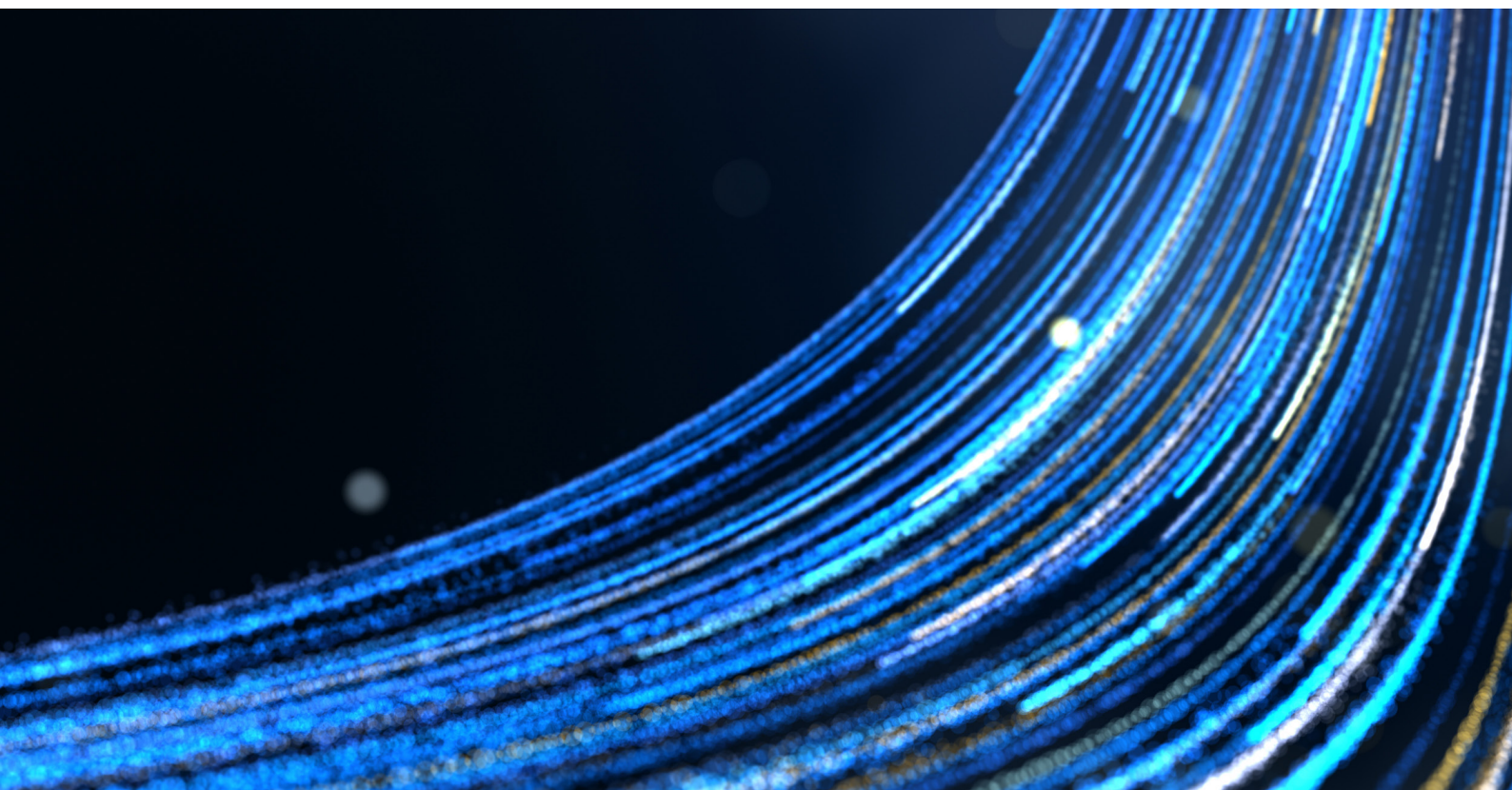
difficulties and maintain fairness to telecommunications operators, supporting such initiatives through financial mechanisms, tax or fee reductions would be considered to incentivize operators to respond quickly.

The regulation of open access in private areas

The issue of open access in private areas is slowing the spread of fixed broadband coverage. This includes the access network in residential buildings, office buildings, housing estates, and industrial estates. The challenges arise as a result of exorbitant rental charges and inequitable service quality. Thus, open access regulation in private regions will be strengthened by establishing more pragmatic service level agreements (SLAs) and fines to assure service quality and maintenance in the case of a fiber optic network failure.

Establishing a map-based support system for infrastructure sharing

Regulators should have systems to control and regulate infrastructure sharing in order to ensure that applications for infrastructure sharing between operation providers are convenient, transparent, and efficient. This map-based support system should include the following: 1) poles and underground ducts; 2) fiber optic cable and networks in public and private areas 3) fiber optic network under “Upgrading Telecommunication Infrastructure Project to Drive the National Economy”, and so forth.



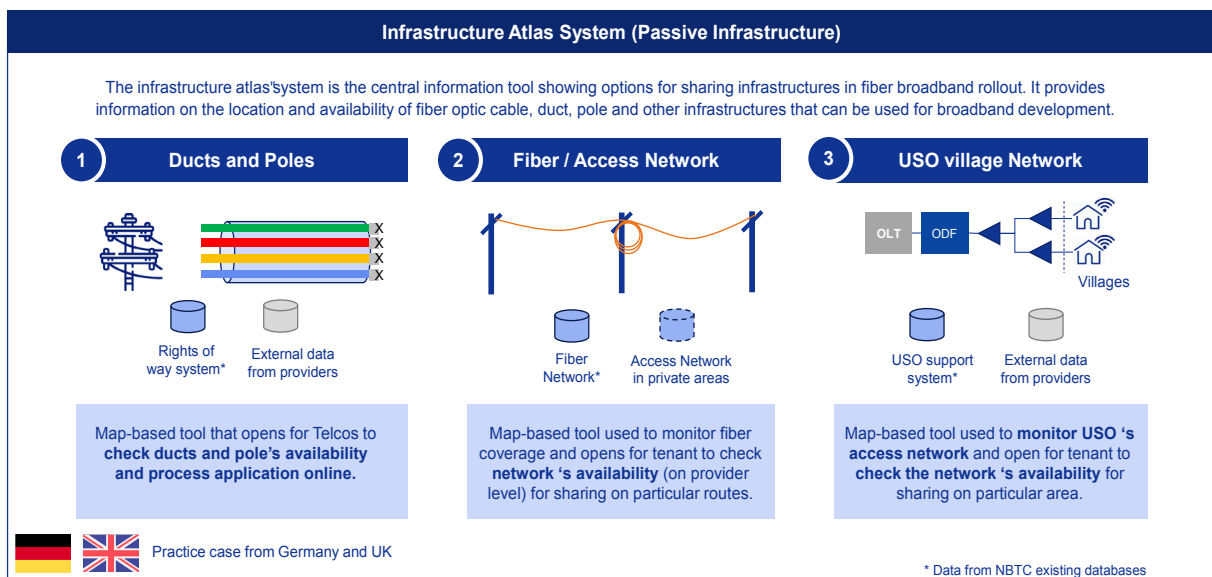
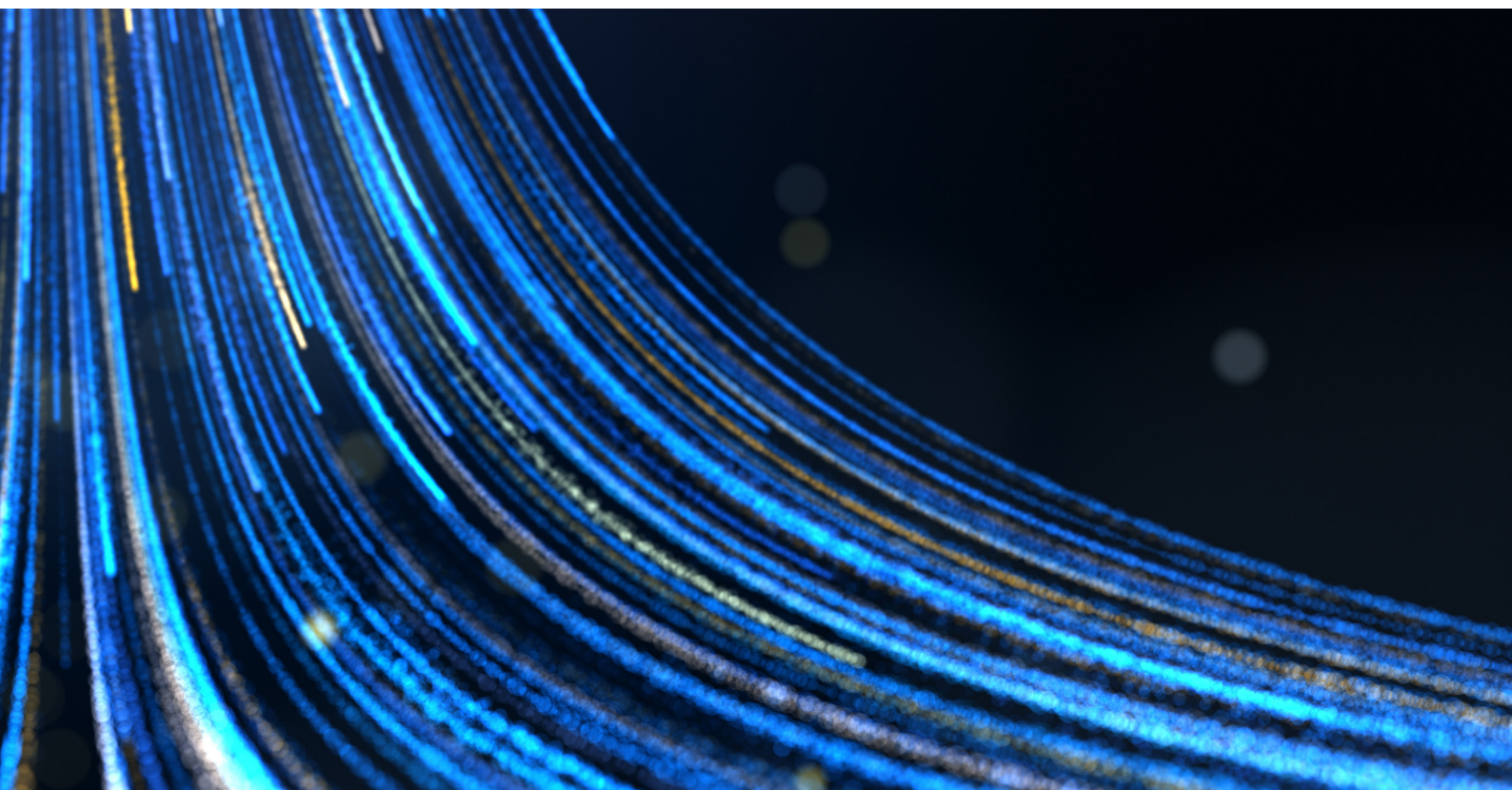


Figure 6-7: A Map-based Support System for Infrastructure Sharing

The map-based system that facilitates infrastructure sharing services should contain a function that enables the requester to list infrastructure providers along the suggested path, check the status and capacity of services, and apply online. It may import preliminary data from existing databases, such as the rights of way system, the permission system for fiber optic cable installation, and the information from the USO project's operation support system.



7 Preparation of Fiber Pre-deployment Policies and Standards

Fiber Pre-deployment is the process of installing a fiber optic network in private areas such as residential buildings, office buildings, housing estates, and industrial estates prior to receiving a request for internet broadband service. In public areas, telecommunication operators could apply for permission to install the fiber optic cable on poles or through ducts, such as the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA), the National Telecom Public Company (NT), and The Krungthep Thanakom Co.,Ltd. However, telecommunications operators must contact or enter commercial deals with landlords to develop the fiber optic network in Private Area. The Current Situation for Fiber Pre-deployment in Private Areasrators to expand their fiber optic network and providing services.

7.1 The Current Situation for Fiber Pre-deployment in Private Areas

In Thailand, fiber pre-deployment in private areas can be classified into 4 scenarios, each with distinct benefits and downsides that affect the broadband market differently, as seen in Figure 7-1.



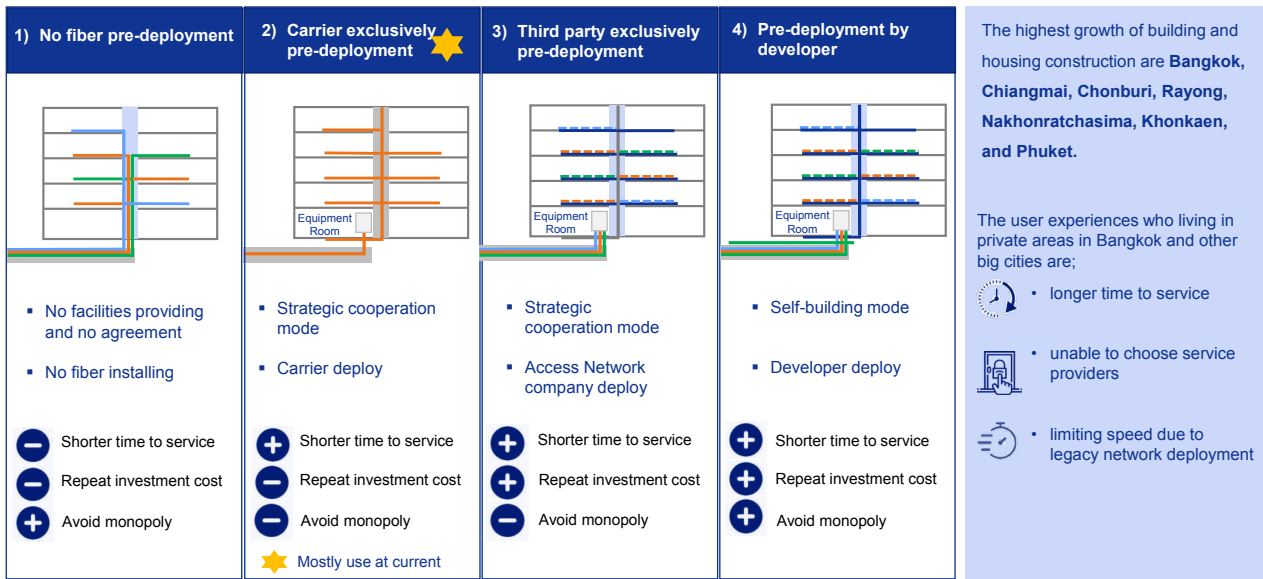


Figure 7-1: The Four Scenarios of Fiber Pre-deployment in Private Areas in Thailand

Scenario 1: Fiber deployment is no pre-installation (No Fiber Pre-deployment). Fixed broadband operators are unable to deploy services instantly due to the lack of fiber infrastructure. The fiber optic cables must be laid beginning at the access point and continuing through the building or private areas to the end users. If subsequent fixed broadband operators intend to provide services in the same private areas, they must reestablish fiber optic cables to connect to the building or private areas. As a result, investment becomes redundant and ineffective. However, this No Fiber Pre-deployment solution enables all fixed broadband operators to compete on a level playing field. Additionally, this would enable all service users to make an alternative operator selection based on service quality.

Scenario 2: Operators Exclusively Pre-deployment, the strategic cooperation mode is when a fixed broadband operator enters into an agreement with the owner of a building or a private area to become the exclusive pre-deployment providers of fiber pre-deployment for the duration of the agreement. A fixed broadband operator can rapidly connect customers due to fiber pre-deployment. However, operators exclusive pre-deployment is regarded as a fixed broadband service provided as the sole monopoly operator for the term of the agreement, and the exclusivity period may be extended if no other fixed broadband operators join the agreement. This mode therefore tends to cause a permanent monopoly. Alternatively, after the term of

the agreement ends, another fixed broadband operator may offer a second fiber pre-deployment deal, mandating investment in redundant fiber pre-deployment with the first operator. Fixed broadband operators are unlikely to lease fiber pre-deployment in private areas to competitors, and the initial operator is unlikely to open its networks to competitors. However, strategic cooperation is the most frequently used form of operation at the present, as a fixed broadband provider with a dominant position in the private area would considerably gain from business.

Scenario 3: Exclusively third-party pre-deployment, a fiber optic network provider enters an arrangement with the owner of a building or a private area to become the exclusive fixed provider responsible for installing and offering fiber optic networks for the agreement period, which is sometimes referred to as strategic collaboration mode. Third party exclusive pre-deployment is distinct from operators exclusive pre-deployment in that the fiber optic network was installed in advance by the fiber optic network provider that provides wholesale access to fixed broadband operators. Fixed broadband operators might link their customers instantly to their offerings. This scenario enables the opening of fiber optic networks in a private area, which can be accessed by all fixed broadband operators. As a result, it has a higher competitive edge than scenario 2. (Operator Exclusively Pre-deployment). However, the third-party provider will become the sole provider of fixed fiber pre-deployment in that private area, with the authority to decide the rental pricing and service quality level.



Scenario 4: Self-building mode is when a real estate developer or private landowner installs a fiber optic network and enables fixed broadband operators accessing to the services. Fixed broadband operators can immediately connect to the signal and begin delivering services to end customers without having to pay rent to a real estate developer or private area owner, as the cost of fiber pre-deployment is already built into the real estate price. Additionally, the equipment, which includes the telecommunications control room, is treated as a shared asset. This scenario enables fiber optic networks to be constructed concurrently with the construction of the building, resulting in cheaper network installation costs in comparison to the other fiber pre-deployment scenarios. This scenario is the most cost-effective and competitive. However, real estate developers in Thailand have just recently begun to use it for buildings or private areas with high-priced or premium assets.

The four scenarios for fiber pre-deployment in private areas indicate that fixed broadband users will face challenges such as delayed service, inability to choose a fixed broadband operator, and possibly inability to receive the required level of service in private areas without fiber optic networks (or relying only legacy technologies, such as copper cable network that not fluently support giga broadband). Fixed broadband users in Bangkok and major cities such as Chiang Mai, Chonburi, Rayong, Nakhon Ratchasima, Khon Kaen, and Phuket are more likely to face these challenges than users in other provinces, as these provinces have a rapid trend of private sector expansion, including residential buildings, office buildings, and housing estates. Bangkok and vicinities accounted for 40% of all residential development permit applications in 2019. Additionally, the housing business expanded and concentrated in those six major cities, with around 23%⁷⁷ of residential construction applications.

⁷⁷The housing industry outlook (6 main provinces), Krungsri, 2021-2023

7.2 International Best Practices for Policies Regarding Fiber Pre-deployment

As discussed previously, one of the issues associated with expanding fixed broadband coverage using fiber optic networks is providing fixed broadband in residential buildings and private areas. A number of nations, notably those who are leaders in the development of fiber optic networks for fixed broadband services, have established several best practices on this subject. The study on fiber pre-deployment rules and standards was undertaken utilizing best practices from the People's Republic of China, Singapore, France, and the United Arab Emirates.

7.2.1 The People's Republic of China

The People's Republic of China developed a fiber optic network growth strategy in 2011 that included infrastructure sharing and efforts to limit monopoly access. In 2013, the National Development and Reform Commission (NDRC) developed policies for fiber pre-deployment in buildings in collaboration with two primary organizations: the Ministry of Industry and Information Technology and the Ministry of Housing and Urban Rural Development, which are responsible for developing Code of design and Codes for construction and acceptance.

Fiber optic networks have been required to be installed in new buildings prior to occupancy, by constructing communications infrastructure and conducting acceptance concurrently with the building's construction. At least three fixed broadband operators must be supported by the cross-section of communication ducts, distribution points, and facilities for constructing fiber optic networks in buildings, such as a Telecom Room.

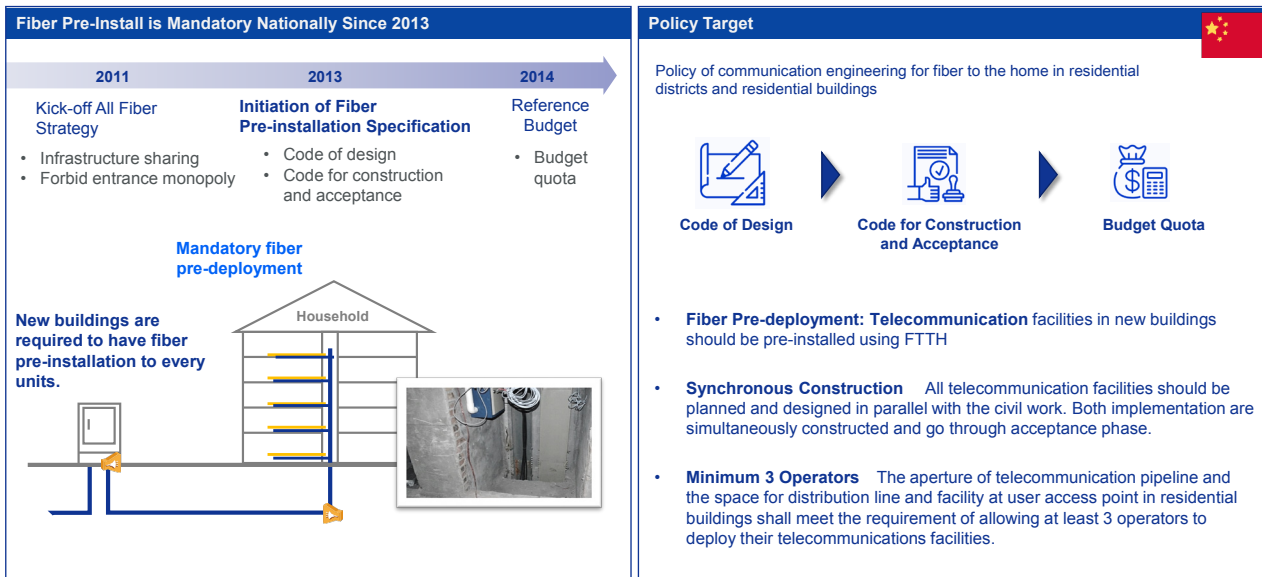


Figure 7-2: People's Republic of China's Policies and Standards for Fiber Pre-Deployment in Buildings

Subsequently, in 2014, a reference budget was created to assist real estate developers in predicting the cost of fiber optic network installation in conjunction with the building's development. In summary, the People's Republic of China has developed a fiber pre-deployment strategy in residential buildings in order to facilitate the development of fixed broadband services via fiber optic networks. Since 2013, all buildings applying for a construction permit must adhere to design codes, construction and acceptance codes, and market reference values for buildings.

7.2.2 Singapore

Since 2010, the Infocomm Media Development Authority (IMDA) has regulated real estate developers and building owners to ensure adequate space and facilities for telecommunications operators by enforcing standards contained in the Code of Practice for Info Communication Facilities in Buildings (COPIF). The most recent COPIF, published in 2018, establishes the obligation of building owners and real estate developers to provide sufficient space, facilities, and accessibility for telecommunication licensees to provide telecommunications services by pre-installing telecommunications infrastructure appropriate to the type and size of buildings. On request, the building owner must allow telecom licensees to install the network in the private area. Additionally, the COPIF defines the responsibilities of licensees of fixed and mobile telecommunications. Compliance with COPIF is a regulatory requirement. If not complied, it would constitute a breach of

the Telecommunications Acts. The following are some of the items that a building owner or developer must provide to a telecom's licensee:

- ◆ Lead-in pipes, underground pipes or manholes;
- ◆ Main distribution frame rooms;
- ◆ Telecommunication equipment rooms;
- ◆ Mobile installation spaces;
- ◆ Telecommunication risers;
- ◆ Coaxial cables with associated splitters and TV outlets; and/or
- ◆ OFC with associated fiber termination points

Moreover, the COPIF prohibits building owners from imposing costs, expenses, service fees, or rents on telecommunication licensees, as well as from imposing extra criteria that result in increased costs or expenses. On the other hand, while the building owner is not liable for utility costs, he or she may consult with the telecommunications licensee over how to calculate them or whether to install a separate utility meter. The building owner should agree on emergency access measures with the telecommunications licensee.



Between 2000 and 2018, the COPIF was revised five times, with the most recent edition issued in 2018. The initial edition of COPIF mandated that building owners or developers provide space and facilities for telecommunications services. The second COPIF needs room for the Next Generation Nationwide Broadband Network's buildings and infrastructure. COPIF's 2013 and 2018 editions mandated building owners to attach at least two and four⁷⁸ cores of fiber optic cable to each room or unit, respectively.

7.2.3 France

France required the installation of fiber optic networks in 2012 as part of the Building and Residence Law R.111-14. The regulation applies to structures granted a building permit after 1 April 2012, but not to temporary structures lasting less than two years. As a result of these regulations, the following pre-installation criteria for fiber are established:

- ◆ A network access point must be connected to the telecommunications network near the entrance, and each room or unit must have at least one fiber optic communication information box.
- ◆ Each residence must have an in-door facility for connecting to the telecommunications network, through fiber optic cable, as specified in the Building and Residence Law R.111-14.
- ◆ Commercial residences or rooms must have at least one fiber optic to provide services. In some cities, a building with more than 12 residential units must have at least four fiber optics.
- ◆ Each fiber optic cable must be labeled as a service location, and telecommunications operators must be able to activate their service at any time.
- ◆ Communication duct must be installed in the common area of the building. Communication cables and connecting devices must be installed with a minimum of a 20 cm clearance above the equipment.

⁷⁸Code of Practice for Info-communication facilities in buildings, IMDA, Chapter 15.2, 15 December 2018

Additionally, there is a standard for fiber optic network installation in buildings that specifies the size of the equipment used for the installation, for example the information box, which must have at least four RJ45 sockets, be 240 x 300 x 200 mm in size, and be able to support data at 1 Gbps.

7.2.4 The United Arab Emirates

The United Arab Emirates has established regulations and standards for the development of fiber optic networks based on the following seven principles: 1) Prevent duplication of investment. 2) Unrestricted network access at no additional expense. 3) Consider future deployment and capacity development of security. 4) Support telecommunications providers in selecting technology. 5) Provide telecom services to customers quickly. 6) Capable of switching service between two operators without requiring on-site support. 7) Customers retain the option of selecting their own operators.

Furthermore, a reference fiber optic network installation model is developed to identify components and their associated definitions in order to facilitate communication and to adhere to the following design concepts and construction criteria:

- ◆ Multi-core optical cables must be employed to maintain competitiveness and reduce investment costs.
- ◆ At least 1 dedicated fiber optic is connected to each home from each operator's OLT.
- ◆ Prepare additional spare capacity for the installation of telecommunications equipment by new operator.
- ◆ Users have the option of choosing one or more service providers and operators. This results in increased incentives for providing higher-quality service.
- ◆ User's information box should be able to hold at least 2 ONTs.
- ◆ Operator has its own dedicated E2E FTTx network and complete service delivery control capabilities.

7.3 Recommendations for Developing Policy, Regulation, and Standard Specification for Fiber Pre-deployment

Fiber pre-deployment policy shall remove impediments to the growth of fiber optic networks in terms of coverage expansion and service quality improvement, notably in terms of speed. The policy should apply to both new building permits and existing buildings where the fiber optic network has been established or has not yet been installed. To provide equal access, avoid monopolization, and establish a reasonable reference pricing, the fiber pre-deployment network should be clearly governed. The fiber optic network must be maintained in accordance with service level agreements (SLAs) and within the budget constraints of the overall construction project. Moreover, fiber-pre-deployment requirements for both indoor and outdoor scenarios should be defined, including design, installation, and acceptance specifications, as well as a reference budget for analyzing the project's cost.

Recommendations for Encouraging Fiber Pre-deployment Policy

Fiber-pre-deployment policies, particularly in private areas for broadband internet delivery, shall be examined and implemented to include the following:

- 1) When requesting for construction approval for a new building, the policy should require the submission of a fiber optic network design. The developer should install fiber optic networks concurrently with the construction of the building. Similarly, as policy requirements are implemented in the Republic of China, a fiber pre-deployment policy is a need for new buildings in every unit. However, according to "The characteristics and types of telecommunications businesses that require a telecommunications business license," the installation of a fiber optic network in a private area (e.g., a residential building) by building owners or the juristic of a condominium or housing estate that already has a fiber network inside the building or private area does not require a telecom license. Appendix C.
- 2) In the case of private areas where fiber optic networks have already been installed by telecommunications operators, including fixed broadband operators (e.g., AIS True, etc.) and fiber optic network providers (e.g., PlanetComm FirstMile), the fiber optic

network in the private area is obligated to provide an open access network at a reasonable rental fee and on an equal footing with other operators. 3) In cases where fiber optic networks have not yet been installed in private areas, fiber pre-deployment should be encouraged through financial incentives, tax deductions, or alternatively through matching funds for joint investment between building owners and telecommunications operators for cost sharing strategies.

Recommendations for Standardizing The Installation of Fiber Pre-deployment

Fiber pre-deployment standard specification should be defined for residential buildings, office buildings, and housing estates, both indoor and outdoor. Furthermore, a methodology for determining the right construction cost should be researched and cost modeling for the industry's reference budget undertaken.

Recommendations for Regulating Open Access of Fiber Pre-deployment in Private Areas

According to the previous section's recommendations on fiber pre-deployment policy, telecommunications operators shall be regulated to allow other fixed broadband operators access to their fiber optic networks in private areas. Telecommunications operators that own fiber optic networks in private areas (e.g., buildings, housing estates, and other private areas) shall update a point of access into a map-based infrastructure sharing support system (Infrastructure Atlas System) to facilitate access. To regulate fiber pre-deployment in private areas, both the establishment of RAO (Reference Access offer) and the standard for calculating rental fees must adhere to the principle of "Telecommunication access and interconnection" (Refer to Infrastructure Sharing Chapter).



8 The Mitigation of Digital Divide

8.1 Thailand's Digital Divide Challenges

Thailand's digital divide challenges can be categorized into 3 aspects as follow:

1. Limitation of internet accessibility via fiber optic network to households in rural areas: Thailand's fiber broadband penetration rate is 30%⁷⁹, while the majority of access are concentrated in the urban areas. Residents in rural areas can connect to fixed broadband via public Wi-Fi, as each village has its own hotspot. Certain villages may have multiple Wi-Fi access points, if they have a school, a sub-district health promotion hospital, a USO Net location, or a USO WRAP location⁸⁰. However, employing Wi-Fi technology has limitations in terms of distance and number of users.

2. The disparity in the quality of fixed broadband service between urban and rural areas: In urban areas, the average fixed broadband speed is 191/1581 Mbps (download/upload), whereas rural areas have a fixed broadband speed of 30/1082 Mbps, with the exception of 10,000 rural villages that have had their speeds increased from 30/10 to 100/5083 Mbps. To summarize, the fixed broadband speed in urban and rural areas varies greatly.

⁷⁹Calculated from Thai Telecom Industry Database, NBTC, 2020

⁸⁰USO implementation result, USO, 2020

⁸¹Global Index, Speedtest by Ookla, 2020

⁸²USO, loc. cit.

⁸³The village broadband internet project, MDES, 2019

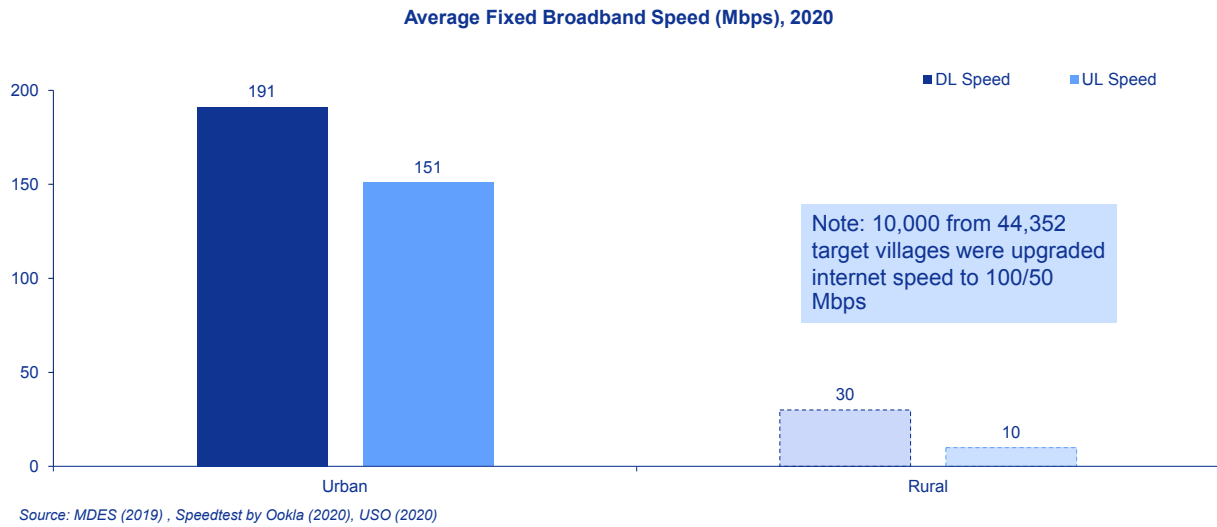


Figure 8-1: Comparing Fixed Broadband Speeds in Thailand's Urban and Rural Areas

3. The disparity in internet users across urban and rural areas: Urban areas have an internet penetration rate of 84%, while rural areas have a penetration rate of 73%⁸⁴. To summary, urban and rural areas have drastically different percentages of internet users.

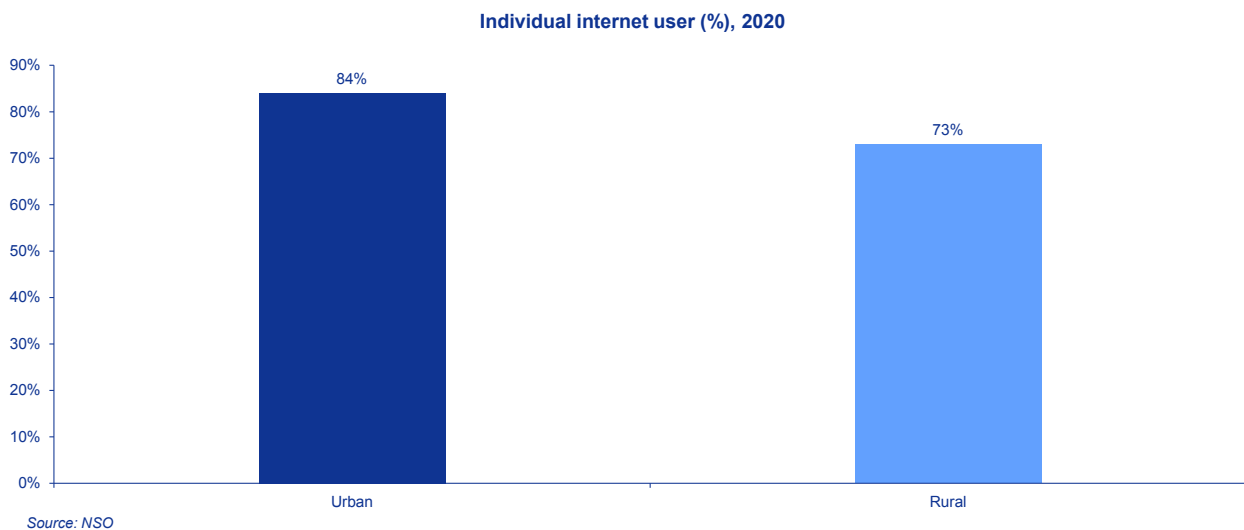


Figure 8-2: Comparing The Percentage of Internet Users in Thailand's Urban and Rural Areas

⁸⁴National Statistical office (NSO), 2020

The Covid-19 pandemic has aggravated Thailand's digital inequality problem, which has become more acute as a result of people's shifting lives or the emergence of a new normal. The new normal has resulted in work-from-home opportunities and distance learning, necessitating a faster internet connection and more concurrent users. Due to increased demand, rural villages' current fixed broadband (public internet service via Wi-Fi hotspots) infrastructure is insufficient. Additionally, a lack of equipment and information about how to use the internet limits people from taking advantage of digital expansion opportunities such as distance learning, booking COVID-19 vaccinations, or qualifying for a financial government subsidy.

8.2 The Implementation Project for Thailand's Digital Divide Mitigation

According to the NBTC's GIS, Thailand had 74,987 villages in 2017, with 30,635 villages classed as Zone A or Zone B already having internet broadband connectivity, while the other 44,352 villages classified as Zone C (rural areas) or Zone C+ (boundary areas) do not have internet broadband access. To meet the goal of delivering internet service to all villages in Thailand, the broadband infrastructure was created in all villages in Zone C and Zone C+ as part of the project "Upgrading Telecommunication Infrastructure Project to Drive the National Economy".

Rural residents now have access to broadband internet via public Wi-Fi as a result of the installation. Between 2016 and 2019, Wi-Fi hotspots in 24,700 target communities were deployed, with one access point per village and a minimum speed of 30/10 Mbps. and afterwards, 10,000 of them were upgraded to 100/50 Mbps⁸⁵. Between 2017 and 2021, Wi-Fi hotspots were installed in 19,652 target villages for a total of 25,925 points⁸⁶, including 18,722 in villages, 4,380 in schools, 1,623 in USO Wraps, 991 in USO Nets, and 198 in sub-district health-promoting hospitals, with a minimum speed of 30/10 Mbps or 30/5 Mbps when satellite was used.

⁸⁵The village broadband internet project, MDES, 2019

⁸⁶USO implementation result, USO, 2020

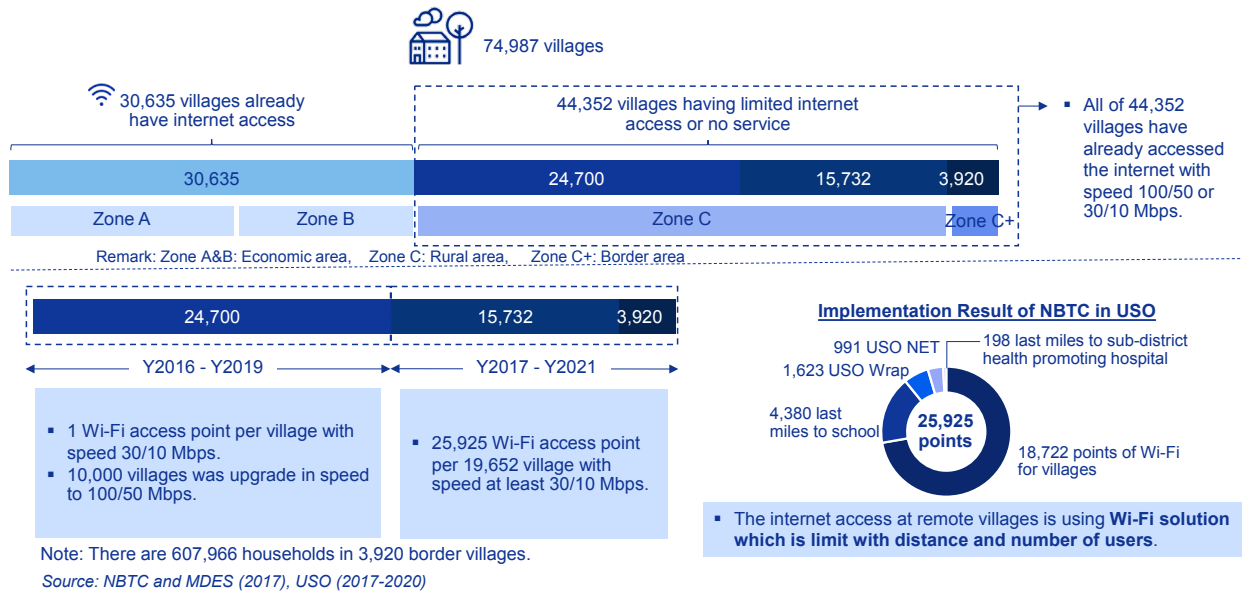


Figure 8-3: The Expansion of Broadband Internet to Target Villages

Currently, a network architecture based on GPON technology has been established by extending fiber optic cables from OLT devices to splitters and connecting the Last-mile to at least one Wi-Fi access point per village. Certain villages may have more than one Wi-Fi hotspots to provide government services such as school-based Wi-Fi, a sub-district health promotion hospital, and school-based USO Net.

Rural residents may be unable to achieve the maximum speed because they access fixed broadband via public Wi-Fi, which has distance and user capacity constraints. For example, in some villages where the speed has been upgraded to 100/50 Mbps, users must be within 25 meters of the access point in order to achieve that speed. Additionally, if a significant number of people are online concurrently, the user will be unable to reach that speed.

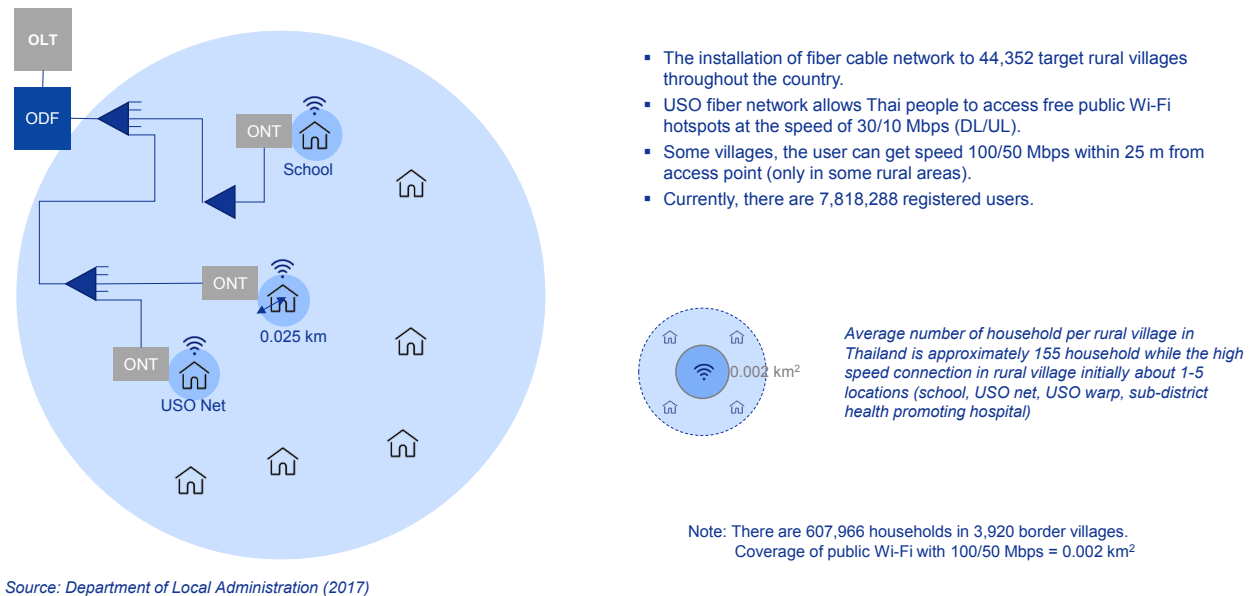


Figure 8-4: The Model of Fixed Broadband Service in Rural Areas

8.3 International Best Practices for Broadband Development in Remote Areas

While future technologies such as the Internet of Things (IoT), artificial intelligence (AI), and blockchain have made considerable strides, roughly half of the world's population remains without access to digital technology⁸⁷. Rural households are less likely than urban or central city households to have internet connection, resulting in a digital divide. To address this issue, a number of nations have enacted the Universal Service Obligation (USO), which aims to ensure universal and fair access to essential telecommunications services for all residents.

8.3.1 Universal Service Obligation in The People's Republic of China

The growing divide between urban and rural areas in fixed broadband expansion has a deleterious influence on economic development. Recognizing the critical nature of broadband infrastructure development, China has made it a priority in its National Economic Development Plan for basic

⁸⁷Connectivity Target, UN, 2025

telecommunications and social services. It intends to deploy fiber optic broadband for telecommunications infrastructure, with the goal of supplying rural areas with fixed broadband at a minimum speed of 4 Mbps in 95% of all villages by 2015 and 12 Mbps in 98% of all villages by 2020.

The federal government, local governments, and fixed broadband operators are collaborating to establish telecommunications infrastructures using fiber optic networks that will require local residents to participate in the construction process and earn profit sharing. The infrastructure will be transferred to fixed broadband operators after five years. By 2015, China had installed telecommunication infrastructure in over 130,000 rural villages. Along with promoting the development of telecommunications infrastructures, China understands the importance of practical application. As a result, it encourages the establishment of e-commerce platforms in order to boost broadband use and the local economy.

8.3.2 Universal Service Obligation in The United Kingdom

Almost one of third of the United Kingdom is serviced by telecommunications operators that have no intentions to invest in broadband infrastructure expansion due to the low rate of return on investment in that areas. Therefore, the United Kingdom has invested in rural broadband infrastructure to provide universal access to basic telecommunications and social services, with the goal of providing fixed broadband at a minimum speed of 2 Mbps in 90% of targeted areas and up to 24⁸⁸ Mbps in 90% of targeted areas in the local economy.

Along with funding the construction of telecommunications infrastructures, the United Kingdom promotes broadband access by subsidizing the cost of installation and establishing a monthly cap. The subsidy applies for people who require broadband service throughout the country. A monthly cap on the cost of using fixed broadband service is set for a minimum speed of 10/1 Mbps. Additionally, it has a scheme to support gigabit broadband growth in rural areas with broadband speeds less than 100 Mbps by distributing vouchers for gigabit broadband installation⁸⁹ to local inhabitants.

⁸⁸The rural broadband program, National Audit office, 2013

⁸⁹Rural broadband, UK Parliament, 2017-2019

8.4 Recommendations to Mitigate The Digital Divide

to mitigate the digital divide between urban and rural areas, the following recommendations are as follow: 1) extend the coverage and capacity of existing fiber optic networks; and 2) increase broadband internet penetration, use, and subscriptions.

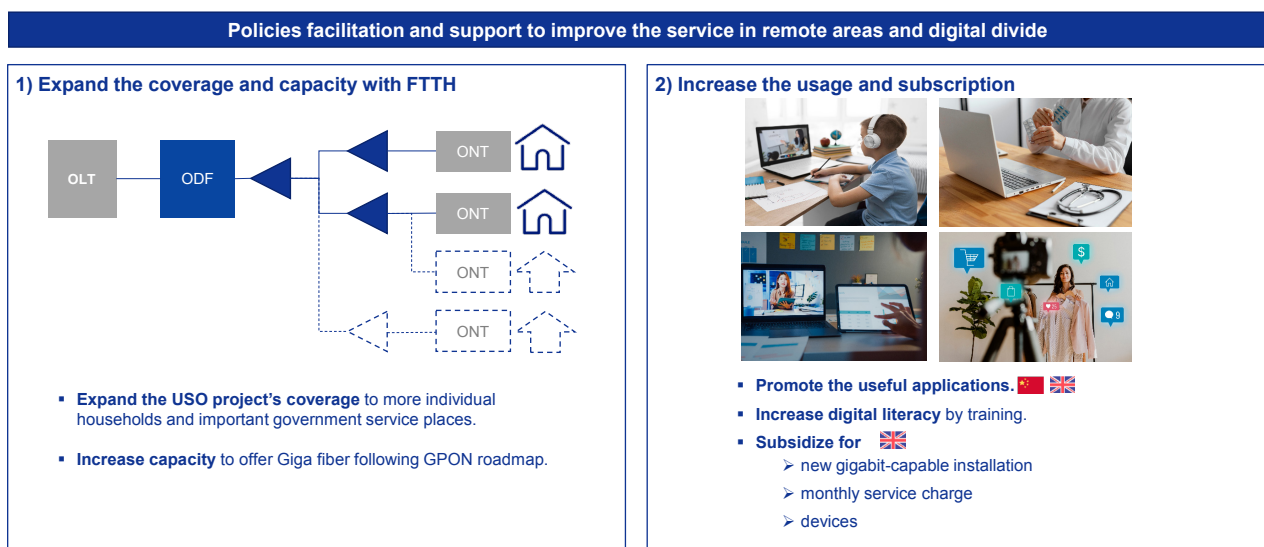


Figure 8-5: Recommendations to Mitigate The Digital Divide

Expanding The Coverage and Capacity of Existing Fiber Optic Networks

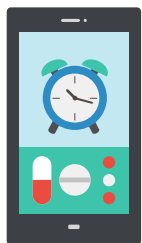
Fixed broadband coverage in rural villages will be expanded using existing fiber optic networks and service offerings ranging from Wi-Fi hotspots to FTTH connections will be enhanced. The last-mile fiber optic cable will connect to individual household and government agencies that require fiber optic connectivity. The existing GPON network may require reconfiguration to meet the desired speed and bandwidth requirements.

Increasing Fixed Broadband Penetration Rate and The Number of Internet Users

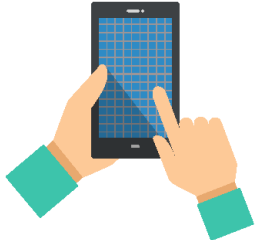
to increase fixed broadband penetration and the number of internet users, it is necessary to promote the adoption of useful life applications for the following services:



1) Educational service applications: Rural areas have a different standard in education system than urban areas. Certain rural areas lack basic instructors and educational resources. To address the issue, online schooling should be implemented. Additionally, online educational software or e-education services will promote non-formal and self-directed learning. However, in order to access an e-education system or remote learning, device support for content access is still required.



2) Health service applications: The quality of public health or medical services is provided in rural areas differs from that in urban areas. Certain isolated villages lack access to basic health care. While some rural villages have sub-district health promotion hospitals, the service quality may be worse than in urban regions due to a physician scarcity, particularly among medical specialists. Also, long-distance trip for visiting a doctor in the city center, along with time consuming and high health care cost, results in patient's inability to continue treatment or sought medical help when their symptoms were severe and difficult to address. In order to address these obstacles, the issue might be handled with the implementation of a telemedicine system. However, telemedicine adoption requires coordination on the side of government agencies to procure services from hospitals and to foster the expansion of online services.



3) Government services applications, communication, public relations, and notification of significant events: Publish a press release, disseminate news and information, or manage a government’s public relations in a rural village (e.g., financial assistance program during the covid-19 pandemic) is challenging, time-consuming, and may result in misinterpretation or non-reception by some people. The issues will be resolved by implementing the notification online application.



4) Specific services/target groups applications: Rural commerce is harmed by a scarcity of tourists or a decline in visitor numbers. Encouraging the use of e-commerce platforms to educate the public will boost trade options and provide greater cash for residents. Additionally, because disabled people encounter hurdles to information access, telecommunications services should be tailored to their specific needs.















Application		ICT Training	Subsidy
<p>Education Services</p>  <p>Challenges</p> <ul style="list-style-type: none"> A lack of teaching staff A lack of teaching materials  <p>E-Learning</p> <p>The device should be supported to students in rural areas.</p>	<p>Public Health Services</p>  <p>Challenges</p> <ul style="list-style-type: none"> A lack of the contagious disease information A lack of available healthcare service  <p>E-Medicine</p> <p>The doctor in the city over-the-internet consults the patient in rural villages.</p>	 <p>Challenge</p> <ul style="list-style-type: none"> Some people in rural area are lack of knowledge and ICT usage.   <p>ICT Training</p> <p>Developing ICT skill for target group in remote areas to deal with digital society and increase digital literacy.</p>	 <p>Challenge</p> <ul style="list-style-type: none"> Many family in rural area have low income and unable to afford high-speed internet   <p>Subsidy</p> <p>Providing Gigabit Broadband Voucher for</p> <ul style="list-style-type: none"> new gigabit-capable installation, monthly service charge, devices
<p>Government Services</p>  <p>Challenges</p> <ul style="list-style-type: none"> A lack of information from the central government (e.g., social welfare)  <p>E-Administrative Office</p> <p>Government can distribute and exchange information and provide support for emergency, disaster.</p>	<p>Services for special target groups</p>  <p>Challenges</p> <ul style="list-style-type: none"> Slow economic growth in rural area The increase of quality life of disability  <p>Other applications</p> <ul style="list-style-type: none"> Local SMEs can run e-commerce. Disabilities can get telecom services to increase quality of life. 		

Figure 8-6: The Adoption of Useful Life Applications for Different Services

Apart from promoting application use, as discussed previously, ICT skill training is critical for enhancing digital literacy and awareness due to a lack of understanding and experience in the use of information technology among some residents of rural areas.

However, the above-mentioned measures to mitigate the digital divide may require financial assistance to cover the costs. Certain rural residents continue to lack the financial resources necessary to enroll in broadband internet services and purchase the necessary equipment to connect. As a result, low-income families may require financial assistance for installation, monthly fees, and equipment. Subsidies shall be considered adequately in terms of technique and magnitude.



9 Operation Plans

Considering the current issues and circumstances impeding the growth of fixed broadband services, particularly the issue of digital divide outlined in the prior chapter. It results in the recommendations and the implementations of four operation plans: 1) The regulatory oversight of passive infrastructure sharing 2) Repulsion Fiber pre-deployment policies, regulations, and standards in private areas 3) Mitigation of the digital divide 4) Creation system to facilitate and promote the adoption of related technologies. They are summarized in the figure below.

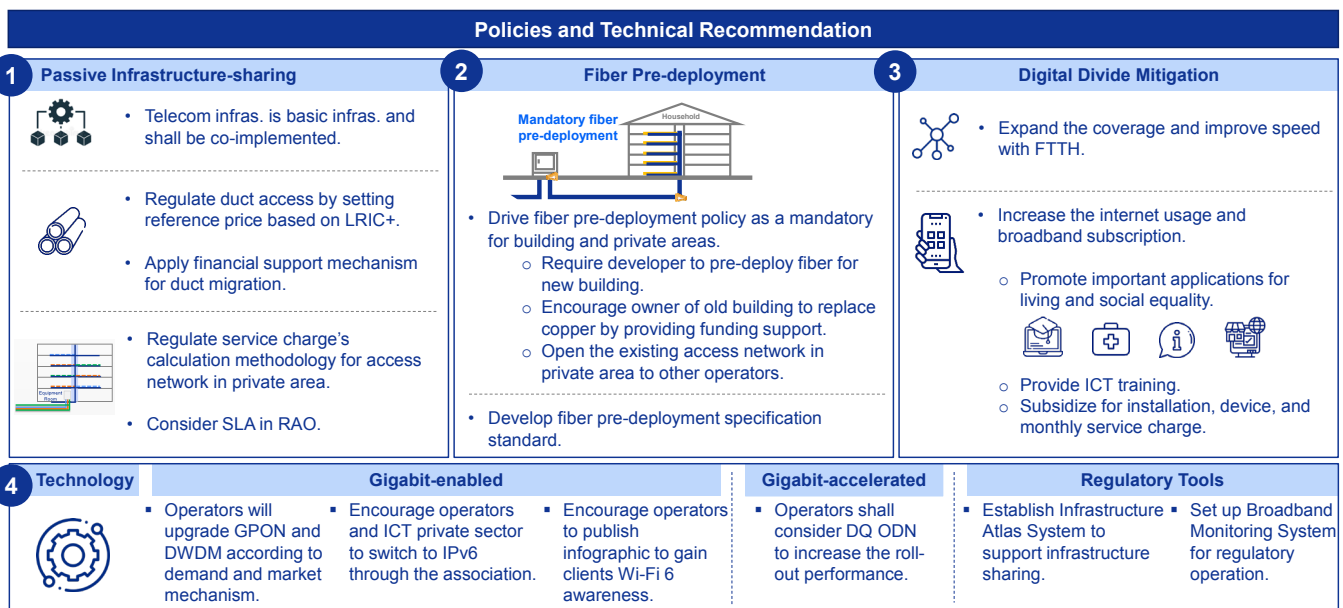


Figure 9-1: The summary of policies, regulations and technical recommendations for fixed broadband development

1) The Regulatory Oversight of Passive Infrastructure Sharing

- ◆ Establish an information center for the collection of infrastructure project plans with the purpose of coordinating the extension of infrastructure projects between the infrastructure project developers and telecommunications operators

- ◆ Enhance duct access reference pricing regulations and examine relevant calculation standards, such as LRIC+, for determining the reference price, as well as financial tools to support telecommunications operators for underground cable relocation project.
- ◆ Conduct a review and enhancement of the regulations governing open access to fiber optic networks in private areas by raising the regulatory level in terms of enforcing calculation requirements and conducting an in-depth consideration of the Reference Access offer (RAO).

2) Repulsion Fiber Pre-deployment Policies, Regulations, and Standards In Private Areas

- ◆ Develop policy, regulations and standards for fiber pre-deployment in private areas that will enable broadband operators to instantly access and deliver service. This policy shall apply to new construction applications, existing buildings with fiber optic network installations, and existing buildings without fiber optic network installations. If, however, telecommunications companies pre-deploy fiber optic networks in private areas, they must be governed similarly to how open access fiber optic networks are handled in 1).
- ◆ Develop industry standards for the design, installation, and acceptance of fiber optic networks in private areas, both inside and outside of buildings. Additionally, the reference budget shall be established by evaluating calculation standards and computing industry-standard fiber pre-deployment prices.

3) Mitigation of The Digital Divide

- ◆ Increase fixed broadband coverage in villages to cover essential areas for public agencies and connect the network to households using FTTH technology by expanding the existing fiber optic network from “Upgrading Telecommunication Infrastructure Project to Drive the National Economy”. As a result of achieving both ease of access and speed requirements, it is possible to close the digital divide and raise the quality of fixed broadband to that offered in urban areas. Currently, urban areas can benefit from much faster fixed broadband speeds than rural areas.

- ◆ Increase broadband usage and subscriptions in the following ways:
1) Through broadband networks, encourage the use of useful online applications such as e-learning systems, telemedicine service systems, electronic data management systems, and e-commerce systems. 2) Conduct ICT training 3) Subsidize financial assistance for broadband installation, device, and monthly service charges.

4) Creation System to Facilitate and Promote The Adoption for Related Technologies

- ◆ Install a map-based data support system (Infrastructure Atlas System) to facilitate infrastructure sharing regulation by initializing data from existing NBTC database.

- ◆ Install a Broadband Monitoring System to track the country's fiber optic network growth and the quality of broadband services.

- ◆ Support the adoption of technologies related to gigabit broadband expansion, such as IPv6 and Wi-Fi 6, by encouraging ICT associations to host seminars on how to educate and transition from IPv4 to IPv6 technology, as well as raise awareness about the advantages of Wi-Fi 6 for supporting gigabit speeds. Besides that, fixed broadband operators should upgrade their network equipment both in the transport network and access network following the roadmap of DWDM and GPON technology, respectively, in accordance with demand and market mechanisms. Additionally, DQ ODN technology may be applied to increase the efficiency of fiber optic network expansion.

9.1 The Operation Plans for Infrastructure Sharing

The operating plans include the following: 1) Co-Implementing telecommunications infrastructure and other basic infrastructure utilities, 2) Sharing an underground communication duct, and 3) Open access networks of fiber optic. The figure below depicts the operation plans.

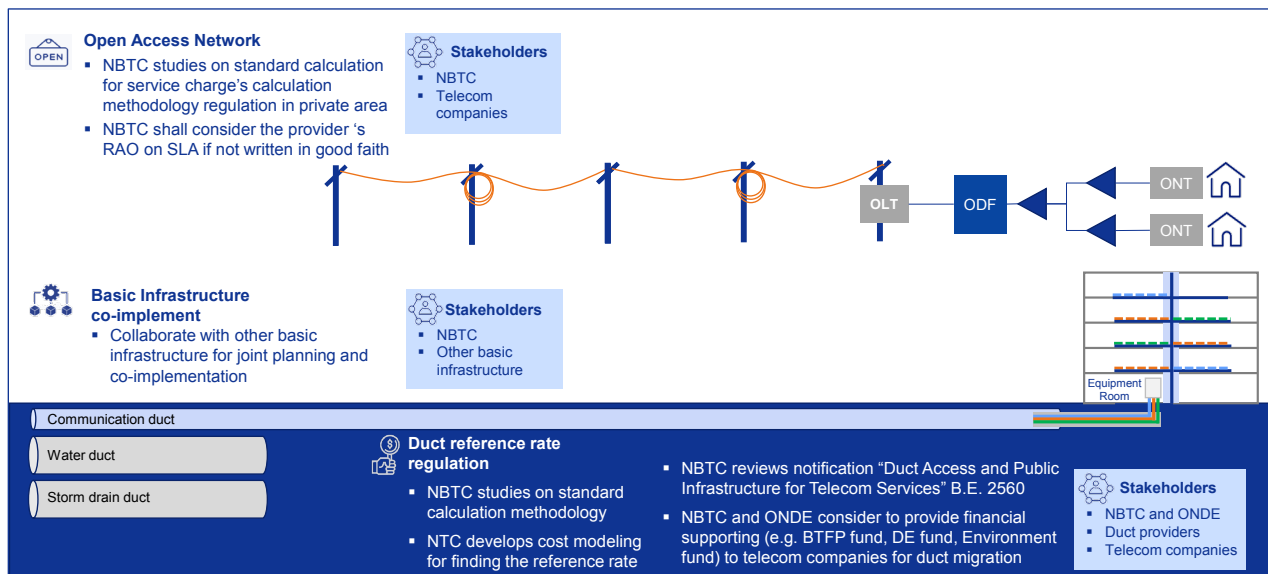


Figure 9-2: The Infrastructure Sharing Operation Plans

9.1.1 Co-Implementing Telecommunication Infrastructure and Other Basic Infrastructure Utilities

The NBTC is charged with organizing collaboration among groups that own telecommunications infrastructure and basic infrastructure utilities such as roads or highways, water or drainage pipes, and underground electrical pipes. The advantages of co-implementation of basic infrastructure include greater construction efficiency and a reduced impact on neighboring inhabitants during the construction phase. NBTC shall collect and distribute fundamental infrastructure construction plans through the Infrastructure Atlas System, a map-based support system that will enable telecommunications operators to obtain online information and later coordinate with utility owners.

9.1.2 Sharing an Underground Communication Duct

Telecommunications operators are perpetually saddled with the expense of renting underground communication ducts, which significantly increase operating costs when compared to renting electrical poles. NBTC should research relevant calculating standards, such as LRIC+, in order to determine the actual cost of renting underground communication ducts. Particularly, the NBTC's regulation of underground communication duct rental prices should be strengthened by switching from "Price Cap" to "Reference Rate". The NBTC's draft notification titled

“ The Highest Rate of Compensation for Communication Ducts Usage,” as well as related notifications such as “The Duct Access and Public Infrastructure for Telecom Services B.E. 2560,” may require revision. Recently, the NBTC has collaborated with entities involved in the communication cable industry to develop underground communication cable relocation plans and to give financial assistance to telecommunications operators for cable relocation compensation. However, for long-term support, the NBTC may consult with a variety of funds that provide the cable relocation compensation to telecommunications operators, including the Digital Economy and Society Development Fund, the Environment Fund, and the Broadcasting and Telecommunications Research and Development Fund for Public Interest (BTFFP).

9.1.3 Open Access Networks of Fiber Optics

Regulations of infrastructure sharing enables other operators to access fiber optic networks, particularly those in private areas. The NBTC should strengthen its regulation of compensation rates by closely monitoring the calculation standard used by telecommunications operators to arrive at compensation prices. The NBTC’s notification on “The Telecommunication Network Access and Interconnection B.E. 2556” may require revision. Moreover, the NBTC should carefully review the Reference Access offer (RAO) in terms of service level agreements (SLAs) and fines to ensure they are reasonable and practical, building confidence in telecommunications operators that serve other operators in private areas.

9.2

The Operational Plan for Policy Preparation, Regulation, and Standardization of Fiber Pre-deployment

According to the recommendations to develop the fiber pre-deployment policy, regulation, and standard specification, specifically in private areas, the operation plan includes 1) driving the fiber pre-deployment policy and regulation, in private areas, and 2) establishing fiber pre-deployment standards specification. The operation plans are illustrated in the diagram below.

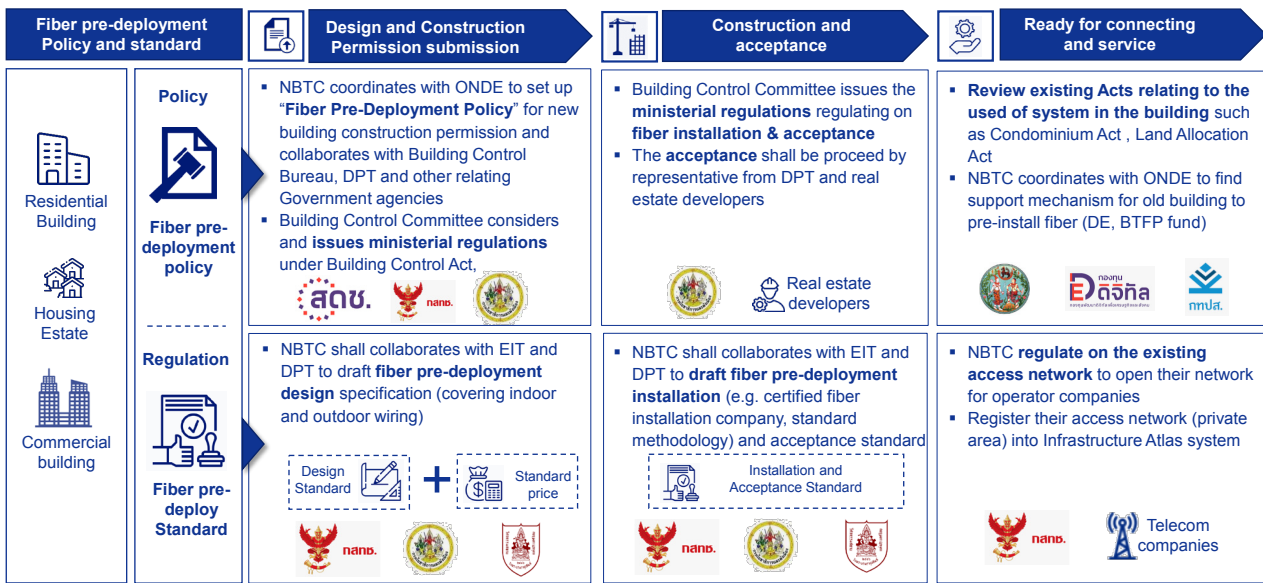


Figure 9-3: The Developing The Fiber Pre-deployment Policy, Regulation, and Standard Specification Operation Plan

9.2.1 Repulsion of The Fiber Pre-deployment Policy and Regulation in Private Areas

The NBTC should engage with ONDE to develop a fiber pre-deployment policy and regulation focused on private areas that would enable fixed broadband operators to provide services immediately. To implement the policies forward, the NBTC and ONDE will collaborate with related government organization, for example, the Building Control Bureau under the Department of Public Works, and town & Country Planning to draft ministerial regulations and submitted to the Building Control Committee for consideration and approval in accordance with the Building Control Act B.E. 2522 under Section 8, local government organization in big cities (e.g., the Public Work Department under Bangkok Metropolitan Administration and municipality) to develop the local ordinance and Industrial Estate Authority of Thailand to revise their regulation in industrial estate areas. To enforce the policy for new buildings, the following procedures are as followed: 1) The process of designing and acquiring construction permits: while submitting a construction permission application, a real estate developer or building constructor is obliged to present a fiber optic network design that complies with ministerial regulation, local ordinance, and other relating regulations. 2) The installation and acceptance processes: A real estate developer or building constructor is required to install fiber optic networks and

conduct the acceptance procedure concurrently with the building's construction and acceptance. The installation and approval processes shall be in accordance with the fiber optics installation and acceptance standards for indoor and outdoor applications set in the ministerial regulations, local ordinance, and other relating regulations. 3) The connecting of processing service: Other related Acts, such as the Condominium Act, and the Land Allocation Act, may be revised. For private areas where fiber optics have been installed and are ready to provide service, the NBTC should regulate telecommunications operators to allow other fixed broadband operators access to their access networks at a reasonable rental fee and on an equal footing, consistent with the regulation of infrastructure sharing mentioned in 9.1.3. Moreover, telecommunications operators must integrate a map-based support system for infrastructure sharing with a point of access for buildings, housing estates, and other private areas (Infrastructure Atlas System).

In the case of private areas where fiber optic networks have not yet been installed, the NBTC shall consult with ONDE and funds (e.g., Digital Economy and Society Development Fund, and the Broadcasting and Telecommunications Research and Development Fund for Public Interest) prior to implementing the financial mechanism or tax deduction as an incentive for developers or landlords. Alternatively, NBTC may assist with fiber pre-installation in existing buildings by matching joint investments between network operators and building owners, or between network businesses, in order to relieve investment costs.



9.2.2 Developing Fiber Pre-deployment Standard

The NBTC will conduct research and develop fiber pre-deployment design, construction, and acceptance standards for both indoor and outdoor scenarios in private areas, which include residential buildings, office buildings, and housing estates. The Building Control Committee will consider the developing standards parallel with the proposed ministerial regulations. NBTC should cooperate with relating government agencies for example the Building Control Bureau under the Department of Public Works, and town & Country Planning, local government organizations in big cities (e.g., the Public Work Department under Bangkok Metropolitan Administration), and the Engineering Institute of Thailand to establish those fiber pre-deployment standards and calculating the reference budget for industry's reference.

9.3 The Operation Plan for Mitigating the Digital Divide

The operating plan, in accordance with the recommendations to close the digital divide, contains two plans 1) expanding coverage and increasing broadband speed, and 2) encouraging the usage of broadband internet. The operation plans are illustrated in the diagram below:



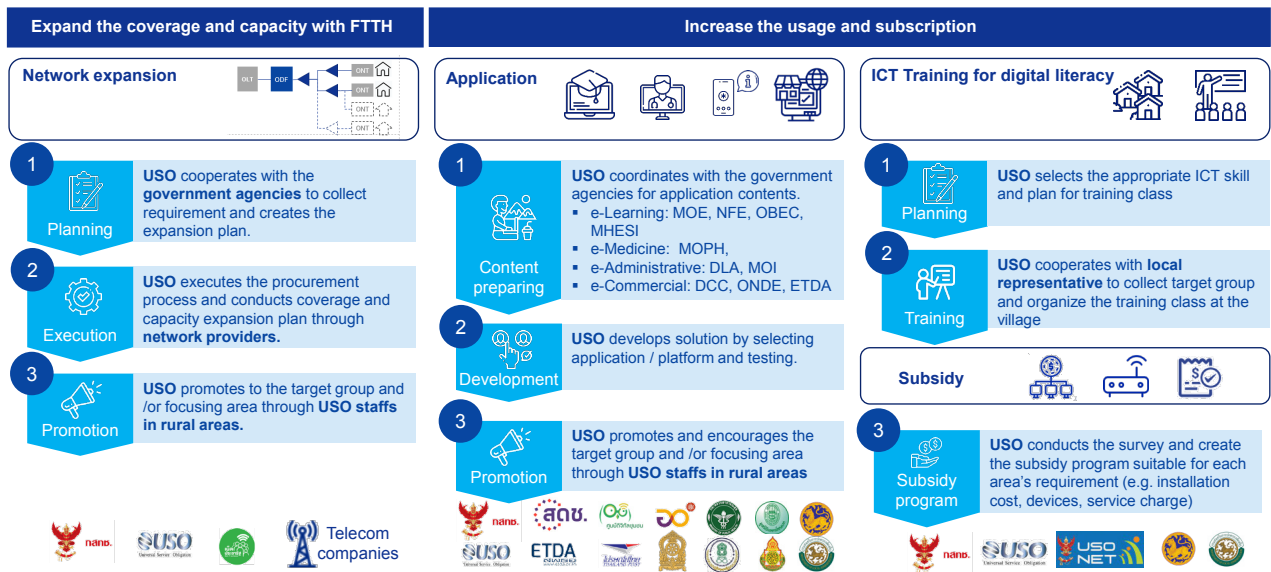


Figure 9-4: The Operation Plan for Mitigating Digital Divide

9.3.1 Expanding Coverage and Increasing Broadband Speed

According to the first recommendation, the Bureau of General Telecommunications and Social Services should expand the coverage of the existing fiber optic network in villages in order to connect critical government agencies and individual households via FTTH technology that satisfies both accessibility and speed requirements. The existing networks were constructed in accordance with the master plan for Universal Service Obligation No. 2 (2016–2021) and the “Upgrading Telecommunication Infrastructure Project to Drive the National Economy,” which aimed to provide high-speed internet in all villages with speeds of at least 30/10 Mbps, such as the Net Pracharat network, as well as rural and border area networks with high-speed internet. The Bureau of General Telecommunications and Social Services should interact with government agencies and the private sector to evaluate demand and design a network expansion strategy. Following that, a procurement process for operators to supply capacity growth should be initiated. Then, through USO Net employees in rural areas, internet broadband usage should be marketed to the target group and/or focus area.

9.3.2 Encouraging the Use of Broadband Internet

According to the second recommendation on the mitigating digital divide, the Bureau of General Telecommunications and Social Services (USO Bureau) should encourage the use of broadband as following:

1) to promote useful applications that require broadband internet access, such as electronic education or online learning, remote medical service systems, electronic administrative offices, and electronic commerce systems. To generate material for each application, the USO Bureau should engage with relevant government departments. The following are some examples of government agencies that collaborate:

- ◆ for developing electronic education or online learning applications: The USO Bureau should collaborate with the office of the Basic Education Commission, the office of the Non-formal and Informal Education, the Ministry of Education, and the Ministry of Higher Education, Science, Research, and Innovation.
- ◆ for developing the remote medical service application: The USO Bureau should collaborate with the Ministry of Public Health and the Rural Doctor Foundation.
- ◆ for developing the electronic administrative office application: The USO Bureau should collaborate with Bureaus, Divisions, Subdivisions and Sections under Department of Local Administration (DLA), and the Ministry of Interior.
- ◆ for developing electronic commerce application: The USO Bureau should collaborate with ICT's village center, Electronic Transactions Development Agency (ETDA), and the Ministry of Digital Economy and Society.

The Bureau of General Telecommunications and Social Services should next develop appropriate applications and platforms for testing and promoting application adoption. Through USO Net workers in rural areas and the Local Administrative Organization, the applications should be promoted to the target group in the focal area.

2) The Bureau of General Telecommunications and Social Services should select the appropriate ICT skills and plans it for a training class. The training session should be organized by collaborating with the Local Administrative Organization.

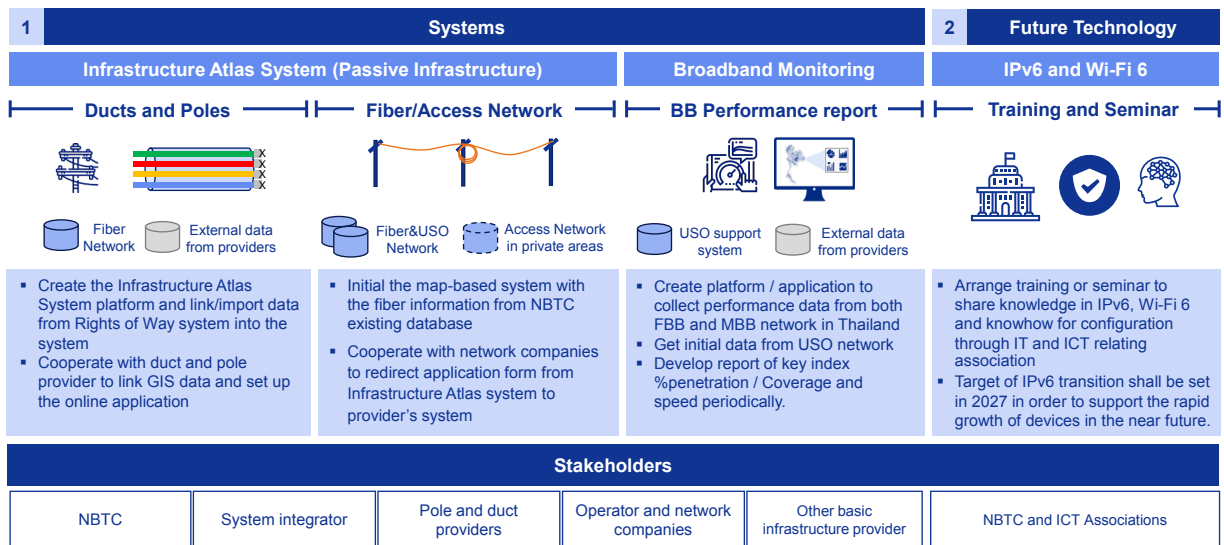
3) The Bureau of General Telecommunications and Social Services should investigate the possibility of subsidizing installation costs, monthly fees, and gadgets by conducting research and designing a subsidy scheme suited to the needs of each area's requirements.

However, the aforementioned operating plan shall be considered to be consistent with Universal Service Obligation Plan No. 3. (2022-2026). Primarily, the Bureau of General Telecommunications and Social Services convened a meeting with 19 key relevant agencies to investigate the difficulties and inefficiencies of communications networks by brainstorming solutions for more efficiently supporting the operation and mission of associated agencies.

9.4

The Operation Plan for Establishing Regulatory Support Systems and Encouraging the Adoption of Related Technologies

By establishing regulatory support tools or systems and encouraging the adoption of related technologies to speed the development of fiber broadband, the transition to gigabit broadband will be accelerated. The figure below illustrates the operation plans.



Source: www.submarinetworks.com

Figure 9-5: The Operation Plans for Establishing Regulatory Support Systems and Encouraging The Adoption of Related Technologies

9.4.1 Establishing Regulatory Support Systems

The NBTC should supply a map-based infrastructure sharing support system to simplify and streamline the application process when applying to share infrastructure, particularly in the ducts, poles, fiber optic cables and networks in private areas. The system may be developed using initial data from NBTC's existing database, which would reduce time and boost efficiency. The map-based infrastructure sharing support system can also be expanded to include data on telecommunications and other basic utility infrastructure, as well as act as a hub for telecommunications operators to collaborate on co-implementation or construction projects between infrastructure providers and government agencies that provide infrastructure services.

Furthermore, the NBTC should supply a map-based broadband monitoring system that allows for the tracking of fiber optic network expansion and broadband quality across the country. To gain a better understanding of the present state of fixed broadband network development, the system should support the compilation of progress reports that compare the current condition to the fiber optic network development goals.

However, the NBTC should seek the aid of system integrators in designing, installing, and integrating the two regulatory support systems stated above. This may enable government agencies or state corporations responsible for basic infrastructure utilities to support and utilize data, as well as telecommunications infrastructure providers (e.g., duct and pole operators) and telecommunications operators.

9.4.2 Promoting the Use of Technologies Related to the Acceleration of Gigabit Broadband

The NBTC should advocate for the adoption of technologies that accelerate the deployment of gigabit broadband, such as IPv6 and Wi-Fi 6. Associations devoted to information technology, such as the Telecommunications Association of Thailand under Royal Patronage, the Thai Information Technology Industry Association, and the Thai Digital Technology Association, should host seminars to disseminate knowledge and know-how about IPv4 to IPv6 migration and to raise awareness about the benefits of Wi-Fi 6 in terms of increasing the efficiency of fixed broadband capable of gigabit speeds. The target to complete the IPv6 transition by 2027 shall be set. To accomplish this, information must be conveyed across a variety of mediums, including infographics.

9.5 Summary of the Operation Plans for Fixed Broadband Development

The operation plans to drive the development of fixed broadband networks are divided into 4 major parts: 1) Infrastructure sharing regulation. 2) Repulsion Policy, regulation, and standard development for fiber pre-deployment in private areas. 3) The digital divide mitigation. 4) The regulatory support systems and the use of relevant technologies to enable gigabit broadband. The operation plans are depicted in the diagram below.








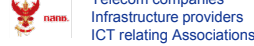
	1	Activities	2	Stakeholders
Infra-Sharing	Ducts	<ul style="list-style-type: none"> Duct reference rate regulation Provide financial supporting to telecom companies for migration 		
	Access Network in Private Areas	<ul style="list-style-type: none"> Regulate on service charge's calculation methodology Consider SLA in RAO 		
	Basic Infrastructure	<ul style="list-style-type: none"> Joint planning and co-implementation 		
Fiber Pre-deploy	Fiber Pre-deployment	<ul style="list-style-type: none"> Fiber pre-deployment policy for new building, old building Financial incentive for old building 		
		<ul style="list-style-type: none"> Fiber pre-deployment standard Design, construction & acceptance and reference budget 		
Digital Divide	Coverage & Capacity Expansion	<ul style="list-style-type: none"> Expand the coverage & capacity with FTTH from existing USO network Promote applications for fulfilling equity of life ICT training for digital literacy Subsidy for usage service 		
	Increase Usage	<ul style="list-style-type: none"> Infrastructure Atlas System Broadband Monitoring System IPv6 and Wi-Fi 6 training 		
System	Regulation Tools and Future Technology	<ul style="list-style-type: none"> Infrastructure Atlas System Broadband Monitoring System IPv6 and Wi-Fi 6 training 		

Figure 9-6: Summary of The Operation Plans for Driving Thailand's Fixed Broadband Development

Policy, regulatory, and technological recommendations, including the aforementioned operation plans, are developed to 1) close the gap between the current state of fixed broadband network infrastructure development and the targets for 2022–2027 2) mitigate the digital divide in rural areas and 3) overcome barriers to broadband network development in order to achieve the following targets:

- ◆ Fixed broadband network with FTTH technology will cover all households.
- ◆ Fixed broadband speed will at least 100 Mbps for rural villages and 1 Gbps for municipality areas, economic zones, and public utility enterprises.
- ◆ Fixed broadband penetration will reach more than 80% of households. The fiber penetration is expected to be increased to 75% of household.
- ◆ Fixed broadband service price will less than 1% of GNI per capita.
- ◆ Digital Economy/ GDP contribution will climb to 25% of GDP.

Reduced network installation costs and time, increased network efficiency, and increased network capacity in terms of speed, all benefit operators and consumers by enabling them to acquire more efficient fixed broadband services at a lower cost. Furthermore, it boosts the national economy indirectly by increasing the contribution of the digital economy to GDP. The construction of fixed broadband infrastructure is an important step forward for Thailand's digital infrastructure, economic development, and social development.



