Getting ready for a new era of fiber broadband

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INTRODUCTION

The fiber-to-the-premises (FTTP) broadband landscape is changing in many ways and operators must adapt to the new reality across the full fiber lifecycle, stretching from network build to installation and operation, as well as other areas such as retail offer design and the business model for the network.

Bandwidth demands continue to rise and with high levels of competition between operators, for example, in areas where there are multiple overlapping FTTP networks, it is not viable for operators to stand still in terms of the bandwidths they offer to subscribers. In this context there is a need for operators to continue to invest in next-generation passive optical network (PON) technologies. Such technologies can also have a role to play in helping to expand the market for FTTP broadband access to enterprises and the use of PON networks to other applications such as smart cities and mobile transport.

Automation and AI are topics of growing importance for FTTP operators and offer promising opportunities for operators to capitalize on prevailing market trends. The use of automation and AI can help operators throughout the fiber lifecycle, for instance, by reducing the costs associated with network build, subscriber installation, and fault remediation. In addition, automation offers the promise of improved service agility, which will become increasingly important as operators look to fully monetize their fiber rollouts while differentiating themselves from competitors.

Operators and investors continue to develop FTTP business model innovation. Operators that previously operated closed networks are now increasingly offering wholesale access. Wholesale only business models where there is a separation between infrastructure and retail service provision are increasingly proliferating across all global regions and are well matched to the preferences of different kinds of investors. Offering wholesale access offers multiple benefits and new types of network sharing-based wholesale broadband hold the promise of additional revenue.

As with other industries, sustainability is an increasingly important element of the FTTP broadband access landscape. Operators must ensure they minimize carbon emissions, which is important from an environmental perspective but can also help reduce operators' costs while addressing an increasingly important area for end users. FTTP is the most sustainable broadband infrastructure, and operators must make sure to maximize this advantage.

Many operators are now placing increasing emphasis on monetizing the FTTP networks they have already built. To do this effectively, operators need to think about the design of their retail offers beyond just speeds. An emphasis on in-home Wi-Fi is an important element for operators to consider, for instance, in terms of developing a CPE centric strategy with premium Wi-Fi hardware. Another area worth investigating is offering end users applications on the CPE which could include parental controls as well as connected home cybersecurity.

Operators have the flexibility to forge their own migration path to next generation PON

Operators have different choices for upgrading to or deploying next generation PON technologies. The important thing for operators to note is that, while there is growing momentum behind the rollout of PON technologies with capacities of 10Gbps and above, there are different technology choices available and different ways of deploying these technologies.

THERE ARE STRONG DRIVERS FOR 10G PON UPGRADES WHICH OPERATORS ARE CONDUCTING

It is increasingly clear operators must offer capacities on FTTP networks beyond those that gigabit-capable PON (GPON) can provide. Bandwidth and speed demands continue to rise, albeit at different rates depending on region and country. Competition between operators is an important driver and, in some cases, multi-gigabit plans are seeing high uptake rates which are contributing to growing FTTP ARPUs.

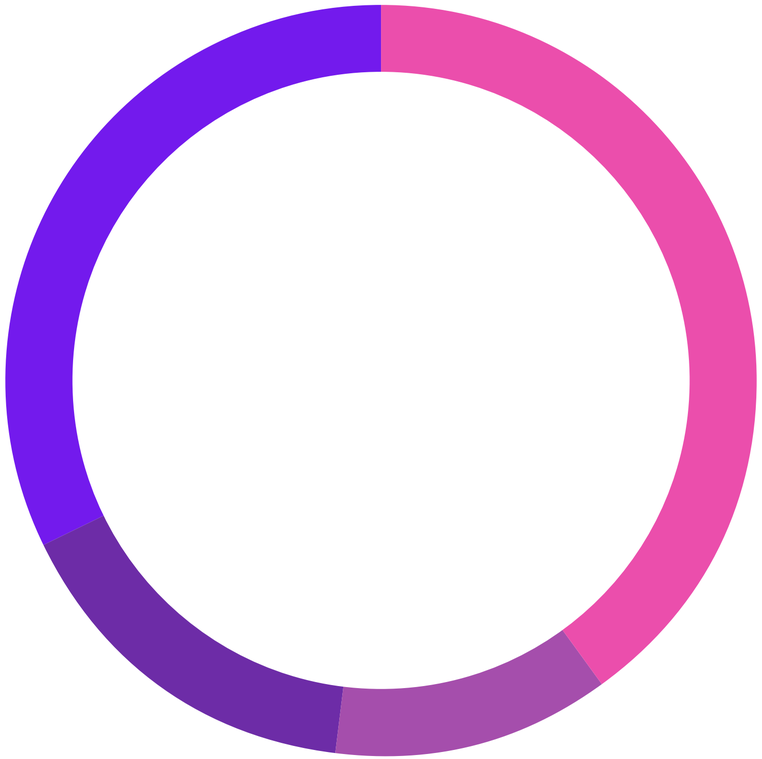
Traffic growth is also an important driver of GPON network upgrades. In many markets regulators are increasingly focusing on ensuring that operators can deliver at the speeds they market. As traffic levels grow, meeting these regulatory targets will become more difficult and, for example, it may be challenging to offer a symmetrical 1Gbps plan with GPON due to upstream capacity limitations.

10G PON upgrades can also actually help operators reduce costs in the longer run. In some cases, if an operator deploys a GPON ONT today there is a risk that as bandwidth demands grow this will need to be replaced with a 10G PON ONT after a short amount of time. This results in a duplication of the ONT hardware costs and potentially entails the need for a costly engineer visit to swap out the ONT at the customer premise. However, upgrades to 10G PON technologies still allow operators to preserve flexibility in their ONT strategies and keep GPON ONTs for customers being served with this technology rather than providing all customers with 10G PON ONTs.

The extent to which 10G PON technologies and more specifically XGS-PON have already become mainstream is demonstrated by the maximum speeds offered by major operators. Many operators offer retail plans with maximum symmetrical speeds of a few Gigabits per second, beyond what could be provided by GPON networks with their shared downstream/upstream capacity of 2.4/1.2Gbps. Across 25 countries in all regions analyzed by Omdia 48% of incumbents offered maximum download speeds of more than 2.5Gbps (see Figure 1).

Some operators have yet to deploy XGS-PON and this can reflect market circumstances. Operators deploying XGS-PON need to make sure the backbone can also fulfil the new bandwidth requirements. The additional costs for XGS-PON optical network terminals (ONTs) in markets with lower broadband ARPUs can also constrain such rollouts. However,

Figure 1: Highest download speeds offered by incumbents, selected countries, July 2024



SOURCE: OMDIA

over time these factors will change, and operators will need the flexibility to quickly and cost effectively upgrade their networks. Deploying combo PON line cards, which support both GPON and XGS-PON on the same optical line termination (OLT) port, offers an attractive solution for such operators. With combo PON, operators need not initially launch XGS-PON and can start by using cheaper GPON only optics and then later activate the XGS-PON functionality and use combo PON optics. Operators can then move the GPON only optics to areas with lower demand for higher speeds, which allows for a cost-effective reuse of resources.

25, 50, AND 100G PON ALL OFFER ADVANTAGES TO FTTP OPERATORS

Some operators want to leverage new technologies beyond XGS-PON to maximize the revenue potential of their networks or compete better. Operators upgrading to 25G PON today will enjoy the benefit of being able to offer plans with symmetrical speeds of at least 10Gbps for the residential and enterprise market as well as being able to capitalize on mobile transport opportunities. 25G PON offers the benefit of an easy and quick upgrade for those that are deploying XGS-PON line cards from some vendors. Moreover, 25G PON can coexist on the same fiber infrastructure as both GPON and XGS-PON and therefore offers operators a simple and cost-effective path to add more capacity to their networks. Additionally, 25G PON is attractive for cable operators who are transitioning to fiber, as they can start with very competitive service offerings and leapfrog their competitors. With over sixty members of the industry multi-source agreement (MSA) group, multiple commercialized ONTs, and over fifteen commercial deployments across the globe, the 25G PON ecosystem is mature.

Operators who have the business case for services that XGS-PON or 25G PON cannot satisfy, will consider 50G PON or eventually 100G PON. The technology choice will depend on the demand and time frame for upgrades. If the demand for these high-speed services arrives before 2030, operators can address them with 50G PON. If the demand is expected after 2030, 100G PON will be available.

A fundamental part of the value of PON FTTP technologies is that they offer a long roadmap for continued bandwidth increases. One reflection of this is there is continuing development work ongoing for PON evolution. This continued innovation ensures

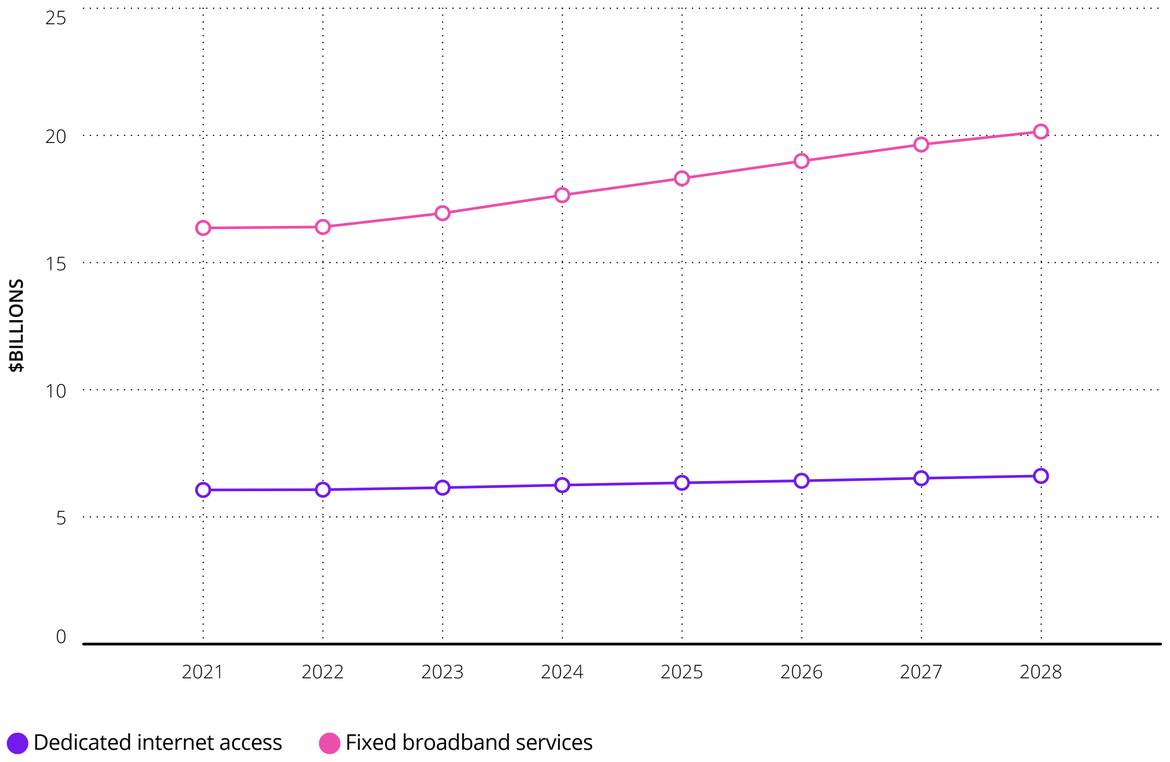
that FTTP operators will always be well placed to meet future further increases in bandwidth demand as and when these occur. The strong roadmap for future PON technologies is also important because this is not matched by other broadband technologies. There is no clear roadmap for DOCSIS cable technologies beyond DOCSIS 4.0 and some major vendors have pulled back from offering DOCSIS equipment. For fixed wireless access there are already diminishing margin returns in terms of increases in spectral efficiency with new cellular technology generations. In this way operators that continue to rely on cable and fixed wireless access will be outmatched as FTTP operators continue to deploy higher capacity PON technologies. Another benefit of 100G PON is that it continues the trend of higher capacity PON technologies offering a high degree of flexibility for operators' rollout strategies. Demonstrations have already taken place which show 10G PON, 25G PON, 50G PON, and 100G PON technologies coexisting on the same fiber infrastructure.

FTTP PON based access for enterprises is a significant opportunity for operators

Another trend in FTTP access is the growing importance of non-residential use cases for monetization of fiber deployments. One significant area of opportunity for operators is to drive revenue growth by selling PON based access to enterprises. There is scope for operators to accelerate revenue growth from SMEs by selling high speed FTTP PON based access to this segment which traditionally has not subscribed to more expensive leased line offers. In this way there is an opportunity for FTTP operators to create an offering with high speeds but with a lower price than for say 10Gbps leased line offers. The existence of this opportunity is reinforced by Omdia's forecasts which indicate that there is little room for growth in dedicated connections for SMEs over the next few years but that there are still substantial opportunities to sell broadband connections to this segment (see Figure 2).

Next generation PON technologies, XGS-PON, 25G PON, and 50G PON now provide plenty of symmetrical bandwidth that can cater to demand from all types of enterprises and can also do so in a more efficient way than traditional point-to-point connectivity. Today, a large portion of enterprises have similar bandwidth requirements to those in the residential segment. However, given the critical importance of broadband for business performance, there is an opportunity for operators to open new tiers of tailored services that offer more features than residential. This approach enables upselling opportunities by moving businesses from residential-like to higher ARPU services.

Figure 2: Dedicated internet access and fixed broadband services revenue, SME segment, 2021-28

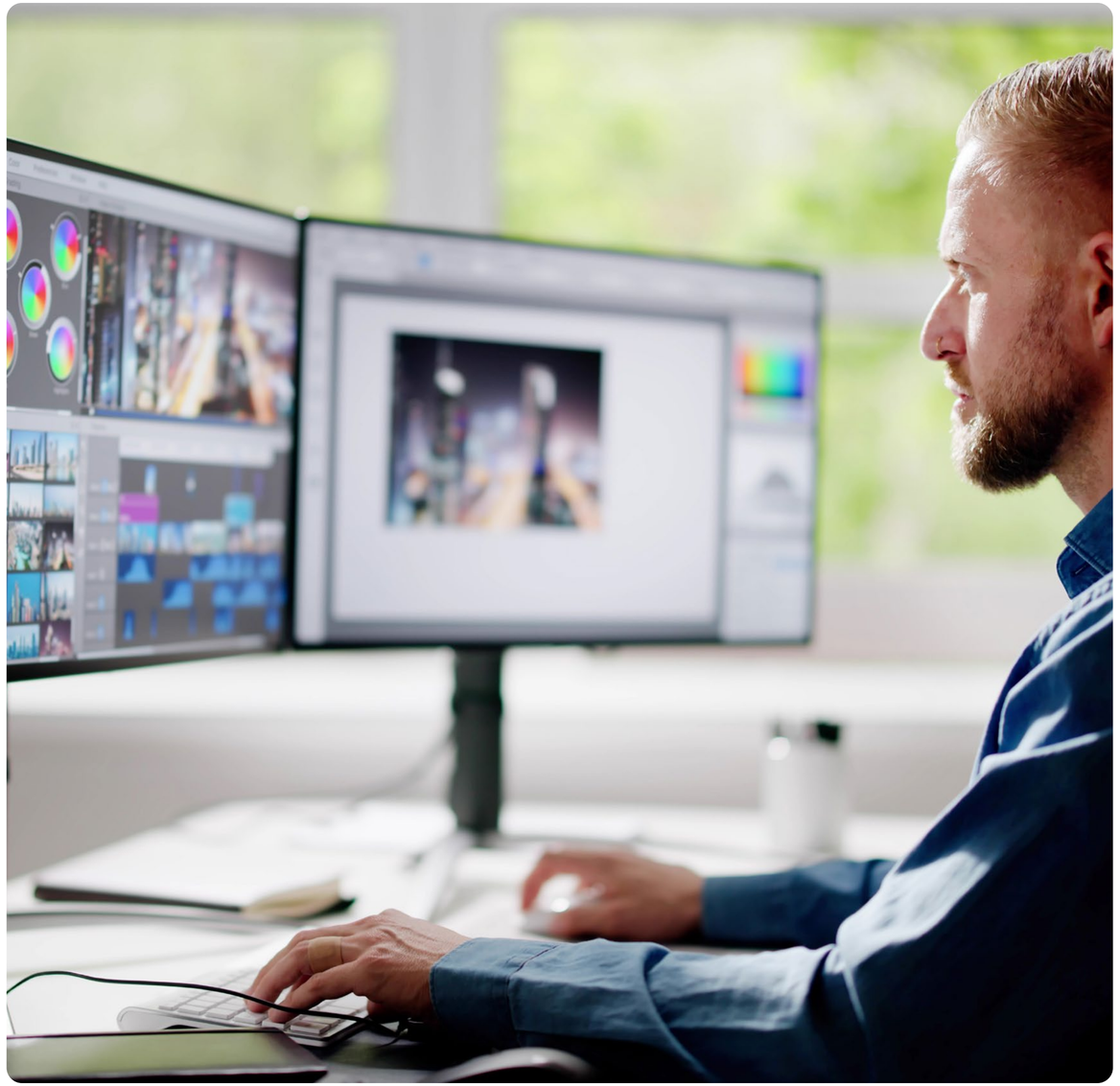


SOURCE: OMDIA

Importantly, real-world examples show the potential benefits to operators of offering PON based access to SMEs. A study from Omdia shows that 80% of operators deploying PON use their networks to serve business customers. For example, Chorus New Zealand is offering PON connectivity to farm 4.0 and other business customers. UK altnet Ogi is using 25G PON based connectivity to serve the Tramshed Tech co-working space in Wales. The co-working space is home to many creative businesses, for example, those working with sports video that send and receive large volumes of data. The high capacity 25G PON network means that the multiple businesses within the hub each have sufficient capacity for their needs. The potential for revenue growth from selling higher speed FTTP PON based access to enterprises is also demonstrated by the prices charged by different operators.

Forward thinking nations are already committing to subsidize upgrades to next generation PON and part of the rationale here is to ensure that businesses will be well placed to develop the country's digital economy. For example, in February 2024 the IMDA, the regulatory authority in Singapore, launched a 10Gbps Nationwide Broadband Network (10G NBN) Grant. The grant will support the deployment of both backend network equipment and front-end user equipment including for enterprise users.

It is also worth noting that there are further opportunities to extend the use of PON networks beyond the residential and enterprise segments and into areas such as mobile transport and smart cities. One indication of the importance of these additional opportunities comes from NetLink NBN Trust the owner of the nationwide FTTP infrastructure in Singapore. The operator reports that at the end of its 2024 financial year the number of so-called non-building address points totaled 2,979 which represented strong growth from the 1,679 at the end of the 2020 financial year. Such non-building address points could be for mobile base station locations or street furniture such as traffic lights for smart city projects.



The importance of automation will grow

Greater automation is a fundamental requirement for operators that want to adapt to the prevailing FTTP market landscape. In the first instance automation offers the promise of reduced operating expenses which will become increasingly important as FTTP rollouts mature. One way in which automation can help reduce costs is through enabling better maintenance and predictive care and so in this way automation can also play a role in ensuring operators have high Net Promotor Scores and low churn rates. Moreover, automation can help to deliver greater service agility which will also become increasingly fundamental, for instance, because as fiber overbuild grows FTTP access alone will no longer be a differentiator and so there will be a need for more service innovation.

Various examples demonstrate how the importance of automation is likely to increase as the FTTP market landscape evolves.

As FTTP deployments mature, fiber subscriber numbers grow, and bandwidth demands increase there will be more opportunities for operators to automate FTTP subscriber installations. If fiber drops and wall outlets are already available, the installation and provisioning of the ONT/CPE can be performed directly by the end user. Given operator benchmarks self-installation of FTTP could save €70 per installation. Self-installation is an obvious choice for subscribers upgrading to higher speed plans where GPON ONTs need to be replaced by XGS-PON ONTs. To understand the potential savings in this area we can assume an operator has 1 million FTTP subscribers from 2.5 million premises passed. If 5% of the end users require an upgrade to XGS-PON to enable a multi gig service each year, self-install provides a noteworthy opex saving of €3.5 million per year. There are additional opportunities for self-installation—think of new tenants in a PON serviced apartment, subscribers churning between FTTP and cable operators, repair activities, etc.

As FTTP subscriber numbers grow there is also an important role for network automation in network and service assurance and these areas are of growing salience to fiber operators as they seek to provide more guaranteed performance levels, including for in-home Wi-Fi networks. As discussed later in this whitepaper, operators are increasingly looking to differentiate themselves on a retail level by focusing on a broader set of performance metrics beyond FTTP access network speeds and including areas such as in-home Wi-Fi speed guarantees as well as greater guarantees on latency. These areas are fundamental for operators and there is a growing focus on ensuring that in-home Wi-Fi network performance does not become a new bottleneck and keeps pace with the growing FTTP access network speeds that are enabled by increasing next generation PON deployments. Intent based assurance can help deliver on operator aspirations in these areas by allowing the network to be monitored continuously and dynamically reconfigured.

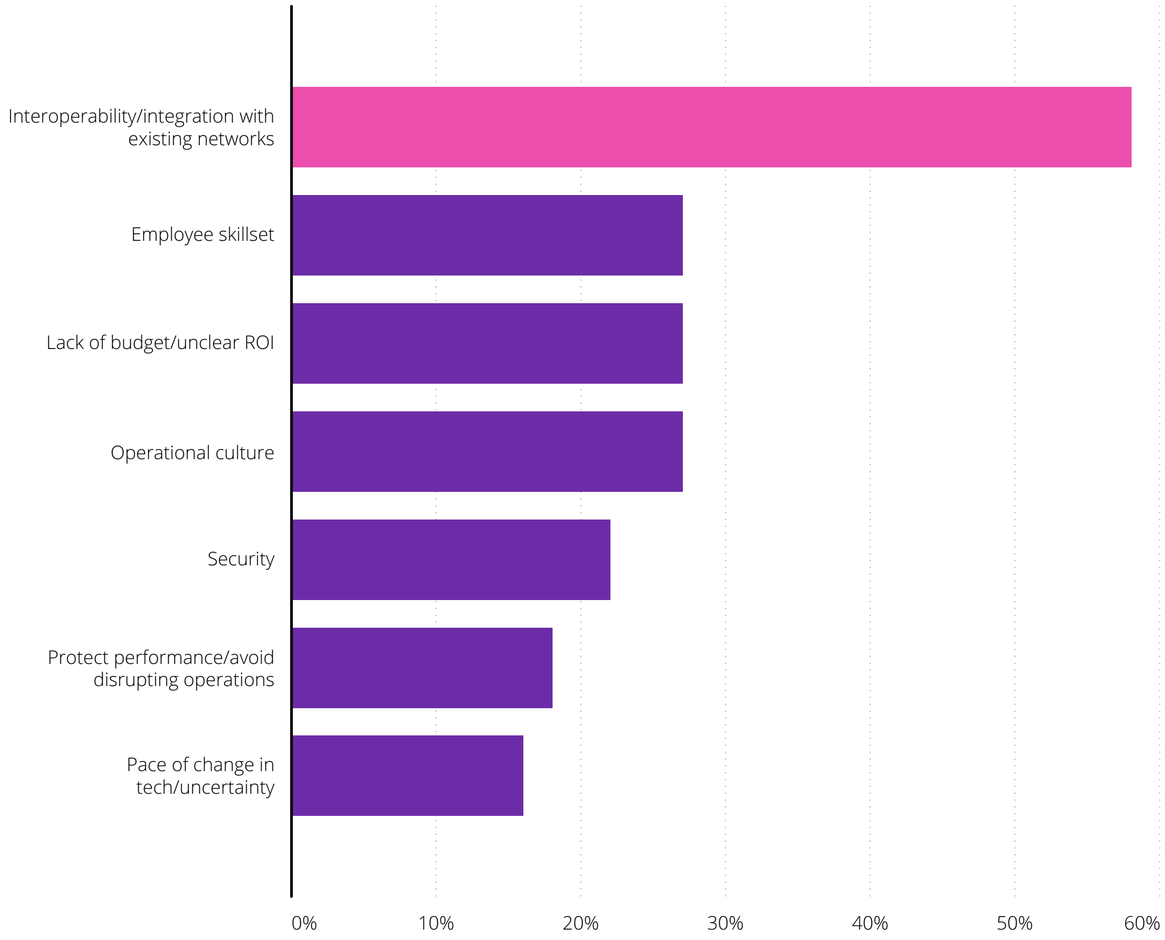
In a similar way automation has an important role to play in network diagnostics and remediation. Improved telemetry data can help deliver automated troubleshooting which then results in reduced mean time-to-repair which in turn can then deliver benefits of reduced churn and improved customer satisfaction. All operators can benefit from reduced fault rates on FTTP versus alternative technologies but faults, both with the access and in-home network, do still occur. Better network diagnostics versus FTTP competitors could be an important differentiator for fiber operators and as FTTP subscriber numbers increase diagnosing and remediating faults will naturally become a greater area of focus for operators.

OPERATORS NEED CLARITY ON HOW THEY WILL MOVE TO MORE AUTONOMOUS NETWORKS

It is clear then that the importance of automation is likely to grow over time, but operators must also understand how to implement it in order to enjoy the full benefits. Operators will firstly require solutions that help them address the challenges they perceive that they face regarding implementing their automation initiatives. As part of a 2023 Omdia survey where operators were asked what their biggest challenge was for advancing their network automation strategy the most popular response by far was interoperability/integration with existing networks (see Figure 3).

Operators will need software for automation that allows them to adapt to the changing FTTP market landscape. One example of how the FTTP market panorama is changing is the trend of growing mergers and acquisitions. In markets like the UK, FTTP operators have proliferated and in order to enjoy the benefits of economies of scale what will likely be a series of mergers and acquisitions has already begun.

Figure 3: What are the biggest challenges to advancing your network automation strategy?
(Select the top two)

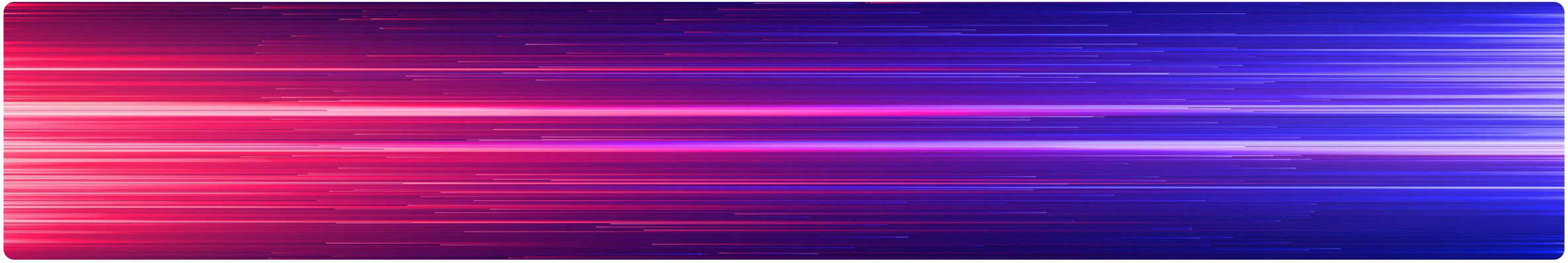


SOURCE: OMDIA, OPERATOR SURVEY 2023

In this scenario it will be probable that the different operators will have been using hardware from different vendors as well as potentially different technologies, for example, because some altnets may have deployed fixed wireless access in more rural areas to complement fiber in urban areas. In this scenario it will be crucial for operators to have software defined network management systems that can manage devices from different vendors and using different technologies. In this way operators will benefit from using open platforms that can support multiple vendors' hardware. Operators will also benefit from the ability to advance services and devices in separate ways, such that it is possible to launch services more rapidly without reference to the OLT or ONT hardware. Automation can also be applied to software development, testing and deployment with the use of continuous integration, testing and deployment frameworks and this could be important in increasing the speed with which new hardware can be launched in the network. The challenge here, as the survey results shown above demonstrate, is that operators will need to adapt their operational culture to enjoy the full benefits of automation.

Operators are looking for standards that can help guide them through their automation journey. One example is the Broadband Forum's Cloud Central Office which standardizes the architectures used for cloud central offices as well as the interfaces for management, control, and orchestration of access and edge network functions. The Cloud Central Office standards can help effectively automate the configuration and operation of broadband networks, for instance, in a multi-vendor scenario. In addition, operators would benefit from platforms that can host applications from third parties because this would deliver best-of-breed options, for instance, when diagnosing network faults. Open APIs can allow third party applications to efficiently sit on top of network management platforms.

Operators pursuing automation with an approach based on openness and standardization will enjoy substantial benefits. In the first instance such operators will see a reduction in costs, complexity, and errors resulting from manual processes. In addition, such network management systems offer the promise of improved time-to-market for new services as the work required to integrate with operators' OSS systems is greatly reduced.



AI adds value throughout the fiber lifecycle

AI offers great potential for operators and a key part of its value is that it offers the possibility to enhance existing automation capabilities. The close link between AI and automation is demonstrated by the results of Omdia's surveys of operators. As part of an April 2024 survey Omdia asked operators what they saw as the main benefit of adding AI to analytics systems and the most popular response was to process data more quickly (see Figure 4). This increased speed is significant because it would then help with automation initiatives.

Operators aspire to use AI for multiple applications and in some cases have already begun to do so. This is again demonstrated by Omdia's survey results from April 2024. Operators were asked which network processes AI would play a key role in automating over the next two years and the responses highlighted a wide range of options, with network optimization the most popular response (see Figure 5).

The fact that operators envisage using AI for multiple applications is also a strong indicator that it will be necessary for them to process greater volumes of data. To meet this requirement, operators need infrastructure that is highly scalable and that allows them to stream and collect data efficiently. SDN networks with cloud native architectures can support telemetry which collects greater amounts of data much more frequently and from more devices than has previously been the case. All these enhancements are important because they mean that operators can monitor their networks in real time, use closed loop automation and enable AI/ML use cases by providing better data inputs for AI/ML models. One practical example of the importance of more regular data collection as an input for AI/ML models is for operators that are planning network deployments. High frequency streaming telemetry is important because it enables the collection of data, showing patterns in bursts of traffic, such as when customers are carrying out speed tests. Analysis of such data will then allow better decision making on the need for FTTP network upgrades.

AI PROVIDES SPECIFIC USE CASES AND BENEFITS TO FTTP OPERATORS

One example of the specific value of AI across the FTTP lifecycle is the use of ComputerVision technology. ComputerVision technology identifies specific patterns in photos or videos. The technology can be used during the build phase of the fiber plant, for instance, to analyze and validate whether fiber cabinets and distribution points have been installed as per plan. The same technology can be used during the home connect phase, to validate installations of the fiber drop, the wall outlet and in particular keep track of the allocation of ports at the distribution point. The latter allows operators to manage the capacity of the distribution points and keep the outside plant inventory in sync with the reality in the field. One example of the importance of this

Figure 4: What is the most important outcome you hope to achieve by adding AI to your analytics systems?

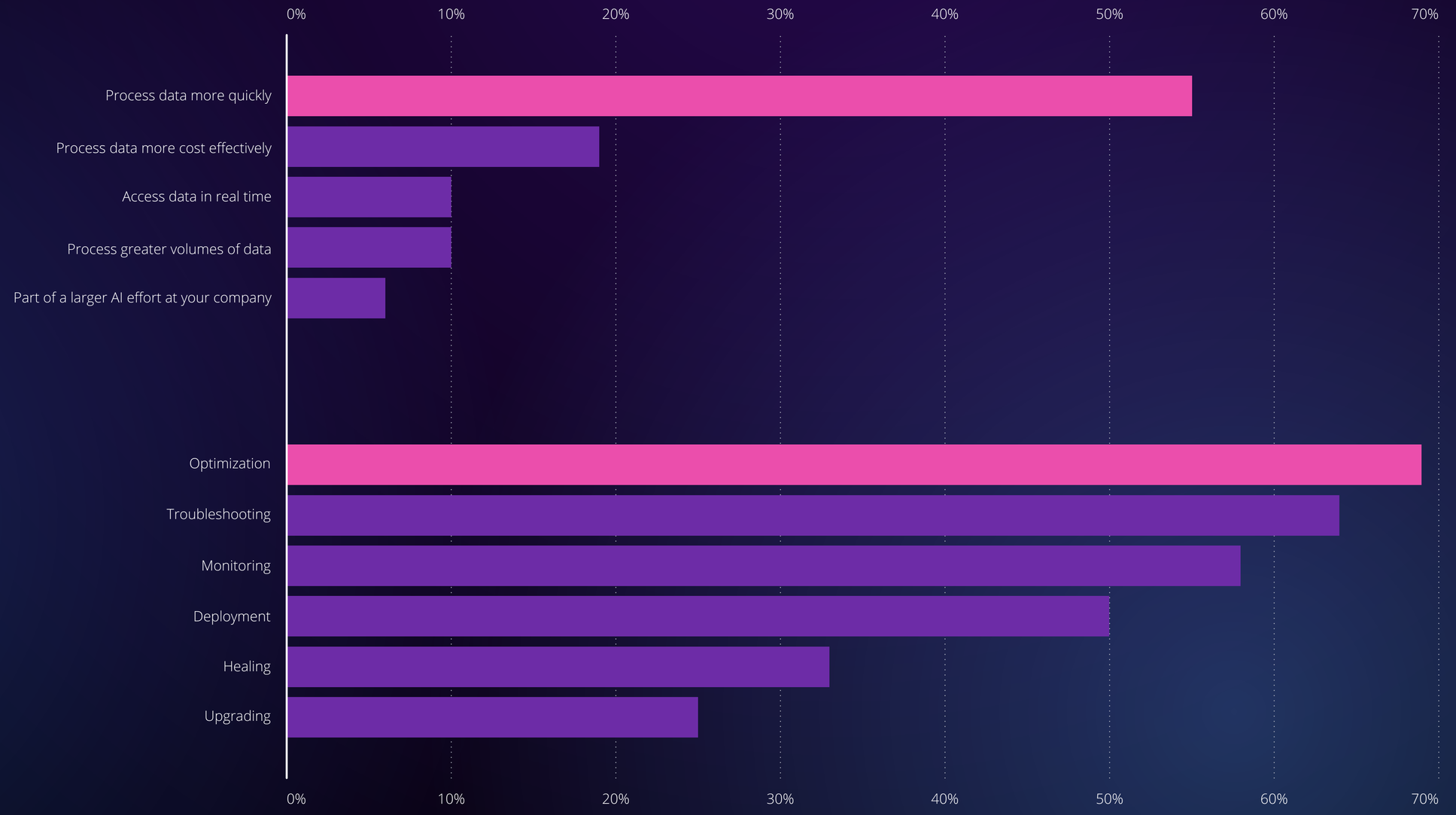


Figure 5: In the next 2 years, which network processes will AI play a significant role in automating?

SOURCE: OMDIA, OPERATOR SURVEY APRIL 2024 — RESPONSES FROM FIXED-LINE OPERATORS, CONVERGED OPERATORS (MOBILE AND FIXED ASSETS) AND CABLE OPERATORS

area is for operators offering wholesale access where multiple retail operators connect at the same flexibility point. This is because when subscribers move between retail operators there needs to be visibility as to which subscriber is connected to which port. In many countries the cost to operators of an FTTP installation is hundreds of US dollars, and operators report that the rate of installations not performed right the first time for technical reasons is at over 10%. Therefore, image recognition tools have the potential to save an average of upwards of $10 per installed premise. These kind of AI tools could also be useful for operators that are looking to provide on the job training to technicians, because the tools are able to provide guidance and recommendations to the workforce as they perform tasks. Overall, such AI infused technology can help operators move to a paradigm where they can use an integrated approach for the validation of passive and active layers of the network, combining, in an intelligent way, AI technology and active PON measurements.

There are further important use cases for AI when operating the fiber network. For example, anomalies could be detected when analyzing the degradation of optical signal power. With the use of AI and parameters set by OTDR and RSSI measurements, operators will be positioned to locate and repair fiber network faults caused by bends in the optical fiber, or issues with fiber connectors, more quickly. The use of AI could also serve to empower field technicians. With the use of generative AI, a field technician could use natural language to diagnose or remediate an issue on site which could deliver important improvements in cost and time-to-repair metrics.

As discussed earlier in this whitepaper, as traffic continues to increase, subscriber bandwidth demands grow, and regulators become more stringent in terms of the rules on broadband speed advertising and marketing, there will be a need for operators to upgrade GPON FTTP networks to 10G PON technologies and beyond. However, operators need tools to ensure they are well placed to plan their capacity requirements. AI has an important role to play in this area by helping use telemetry data to understand the actual traffic patterns generated by subscriber behavior as well as to predict SLA conformance, for instance, in terms of the probability of meeting a speed test requirement imposed by regulatory authorities.

TO BENEFIT FULLY FROM AI, OPERATORS NEED A DATA CENTRIC ARCHITECTURE

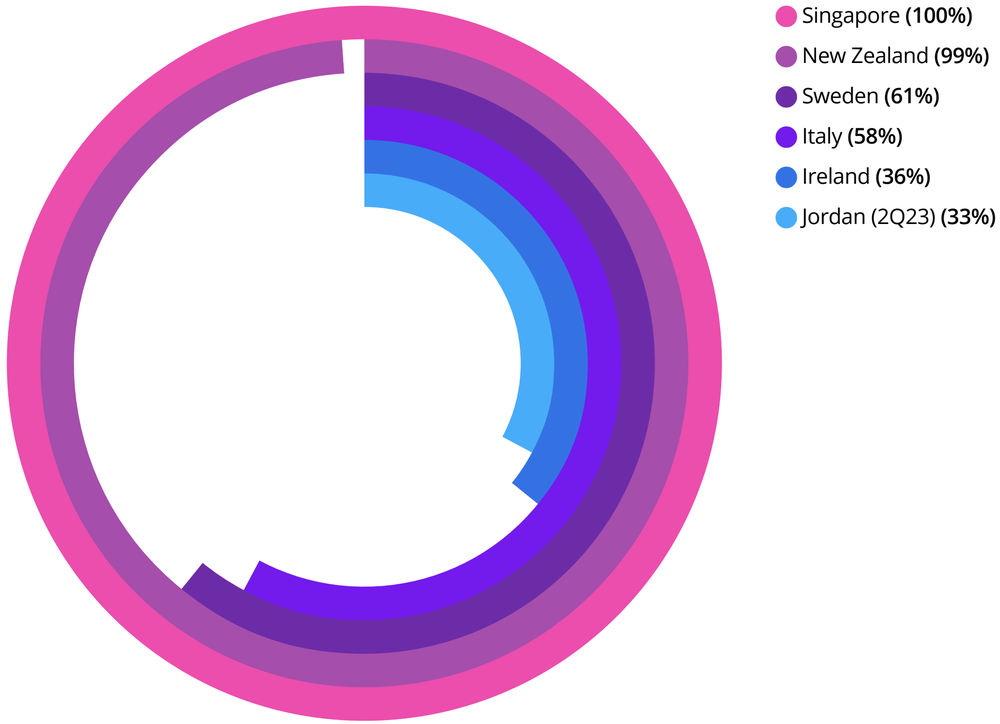
Another area for consideration is that the use of AI requires a data centric architecture where data is analyzed to produce benefits for the operator. However, for operators to fully capitalize on these benefits the data centric architecture needs to be open and accessible to multiple parties across the organization and the data also needs to be of a high quality.

Making data available to multiple parties is critical since there are benefits to combining network data with customer care data to improve the customer experience. Omdia survey results show that there is still work to do for operators in these areas. For example, according to the same previously referenced April 2024 survey of operators, only 36% of operators with fixed assets share network data with any team within the organization. The remaining 64% restrict data to network teams. Nevertheless, the survey results also demonstrate that operators see clear value in such data sharing, and 74% of respondents with fixed network assets stated they did see a benefit in making network data available to others in the organization. To enjoy the full benefits of AI across the organization, operators need to break down some of the barriers preventing greater data sharing, which include a fear of greater work for network operations teams as well as privacy concerns.

Wholesale broadband access is becoming both more commonplace and more sophisticated

Another prominent trend in FTTP access is the growing importance of wholesale broadband access. In the first instance, this refers to operators with their own retail arm also opening up their FTTP infrastructure to third-party retail service providers. Many incumbent operators in Europe are mandated by regulation to provide wholesale access, but more recently incumbents and altnets in Europe and every other global region have opened up their networks for wholesale access on a voluntary basis. There has also been a growth in wholesale only business models where there is a separation between the network infrastructure provider and retail service providers. The network infrastructure provider is a separate, so-called neutral host player which offers wholesale access to multiple retail service providers who then compete for end-customers. Initially this model gained traction in Europe but is spreading to multiple territories all around the world. The importance of wholesale only networks can be observed from the share of retail FTTP subscribers that are served from such networks across different countries (see Figure 6).

Figure 6: Share of retail FTTP subscribers served by wholesale only networks, 4Q23



SOURCE: OMDIA

THE GROWTH IN WHOLESALE BROADBAND ACCESS IS DRIVEN BY MULTIPLE TRENDS

There are several drivers for the growing interest in offering wholesale broadband access. Offering wholesale broadband access can attract multiple ISPs to the network, and the resulting competition in the retail market increases the chances of higher overall subscriber take up which will drive revenue growth for the operator. Another related benefit of offering wholesale broadband access is that, if it attracts multiple retail service providers to the network the risk of these or other players overbuilding the network with their own FTTP rollout is reduced.

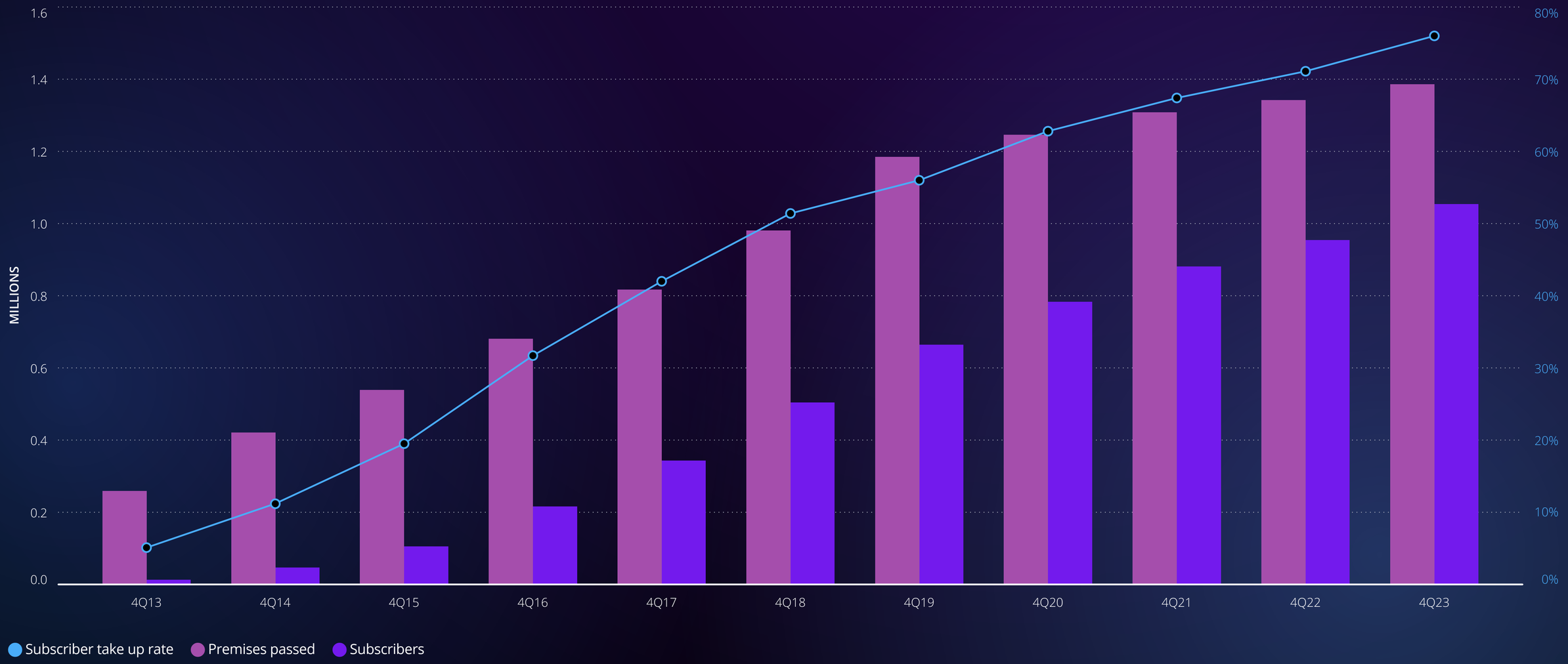
Many operators are increasingly seeing the benefits of voluntarily opening networks that previously operated with a vertically integrated model to third-party retail service providers. One strategy that is commonplace is to first operate a closed network which allows an operator to secure high value early adopter retail customers. The network can then be opened up for wholesale access to increase network utilization in the mass market segment. Regarding wholesale only business models, the separation of network infrastructure from retail service provision can help make the network particularly attractive for multiple ISPs. If there is no separation between network infrastructure provider and its retail service provider arm, then even if such an operator offers wholesale access it may be more difficult to attract other retail service providers onto the network because they may feel it is not sufficiently neutral.

In addition, it may be challenging for a traditional operator alone to fully finance its own FTTP rollout at a nationwide level, including in rural and remote areas. In this way many operators have realized they will not roll out fiber to every corner of the country and have partnered with other operators to expand their reach into out-of-region areas. Other operators have launched fiber carveouts with an infusion of capital, often from private equity firms. This provides operators with more flexibility to continue spending in other areas whilst also reducing debt. A condition of such co-investment models is typically that the network is opened up to provide wholesale access for multiple retail service providers.

There are also other reasons why as FTTP rollouts increase in coverage and extend into more rural areas this may drive growth in wholesale broadband access, although there are nuances to this argument. Costs per home passed in rural areas are high and the lower ARPUs wholesale only network operators could generate compared to the attainable retail ARPUs with a vertically integrated model might make the resulting wholesale only business case challenging. However, in the absence of a purely commercial business case for FTTP deployments in rural areas governments often provide funding for rollout but with the condition that such operators offer wholesale access. Offering wholesale access in addition to first offering retail access could also help generate additional revenue and make a challenging rollout business case in rural areas more viable.

A further advantage specific to wholesale only business models is that they give different players the opportunity to focus on their specialties. Investors in telecoms infrastructure can deploy and manage the network whilst operators can focus on the retail market. Many investors are attracted to FTTP infrastructure because they see it as a stable long-term investment. Wholesale only business models offer the promise for such players of not needing to get involved in areas with which they are less familiar, such as retail service provision.

Figure 7: Chorus New Zealand, UFB FTTP premises passed, subscribers, and subscriber uptake rate, 4Q13-4Q23



SOURCE: OMDIA

WHOLESALE FOCUSED BUSINESS MODELS ARE ALREADY ACHIEVING IMPRESSIVE RESULTS

Many wholesale only players are already achieving strong subscriber uptake rates (for example, see Figure 7 for Chorus in New Zealand) and have secured important retail service providers as wholesale customers.

This success then serves to generate more confidence in the wholesale only business model in other territories. In short, the value of wholesale only business models has already been proven across the globe. Moreover, operators that are offering both retail and wholesale access on their FTTP infrastructure are also achieving noteworthy results. For example, for many Western European incumbents wholesale fiber access represents more than 35% of total FTTP connections.

FIXED ACCESS NETWORK SHARING PROVIDES OPERATORS WITH ADDITIONAL OPTIONS FOR OFFERING WHOLESALE ACCESS

One key consideration for operators is regarding which kind of wholesale access to offer. Some retail service providers, such as traditional incumbents or operators that have historically used copper local loop unbundling offers, might prefer to deploy their own active equipment. However, offering such passive wholesale access is rather rare on a global level and many operators prefer the simplicity of bitstream access, for instance, because they lack their own backbone networks. Another option of growing interest is to use fixed access network sharing, which makes use of software defined networking. The network operator deploys its own OLTs, and fixed access network sharing allows retail service providers to use a virtual slice of the fiber network and manage it themselves with full autonomy. For example, retail service providers have the flexibility to use their own SDN controllers to manage their virtual network slice. The result is that fixed access network sharing provides the best of both worlds for retail service providers in that it can help them avoid large upfront investment in their own active equipment but still provides them with much greater flexibility to develop their own services than with traditional bitstream based models. In line with operator initiatives to widen the use of PON FTTP infrastructure to multiple applications, SDN controllers could also enable network slicing and provide retail service providers with sufficient flexibility to launch premium services for residential users and enterprises. In short, offering fixed access network slices could help generate attractive ARPUs for network operators whilst also maximizing subscriber take up.

For operators offering wholesale access a further benefit of using a software defined fixed network sharing model is that it can reduce opex costs from running the network and limits the need for day-to-day involvement in network operations. For example, a model using an SDN domain controller, enables network orchestration and process automation. Many investors in FTTP infrastructure are looking to limit their involvement in hands-on network management and so a software defined fixed network sharing model can also appeal from this perspective and, for example, allow wholesale only network operators to focus on the management of the passive fiber infrastructure.

Sustainability is vital for operators

Sustainability is an increasingly important consideration for fixed broadband operators. This section of the whitepaper discusses operators' growing emphasis on sustainability, the energy efficiency benefits of PON as well as the potential such benefits offer for cost saving and even revenue generation.

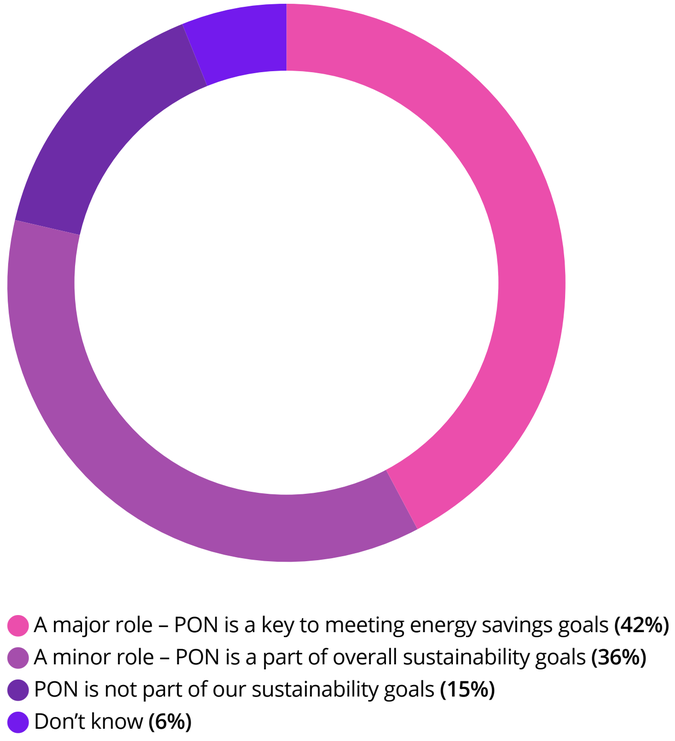
Sustainability as part of operators' strategies is gaining mindshare. The importance of PON in operators' sustainability strategies is shown by the fact that 44% of Omdia operator survey respondents stated that PON plays a key role in meeting their energy saving goals (see Figure 8).

There remains room for operators to build on these results and focus even more on the role of PON in their sustainability strategies. For example, as part of the same survey operators were asked about their tracking of the energy savings offered by PON versus alternative technologies and 35% of respondents stated that they do not track energy savings. This suggests some operators are missing out on a significant area of benefit because as discussed in the next section the power consumption benefits of PON-based access are considerable.

THE ROLE OF PON IN REDUCING ENERGY CONSUMPTION IN BROADBAND ACCESS NETWORKS

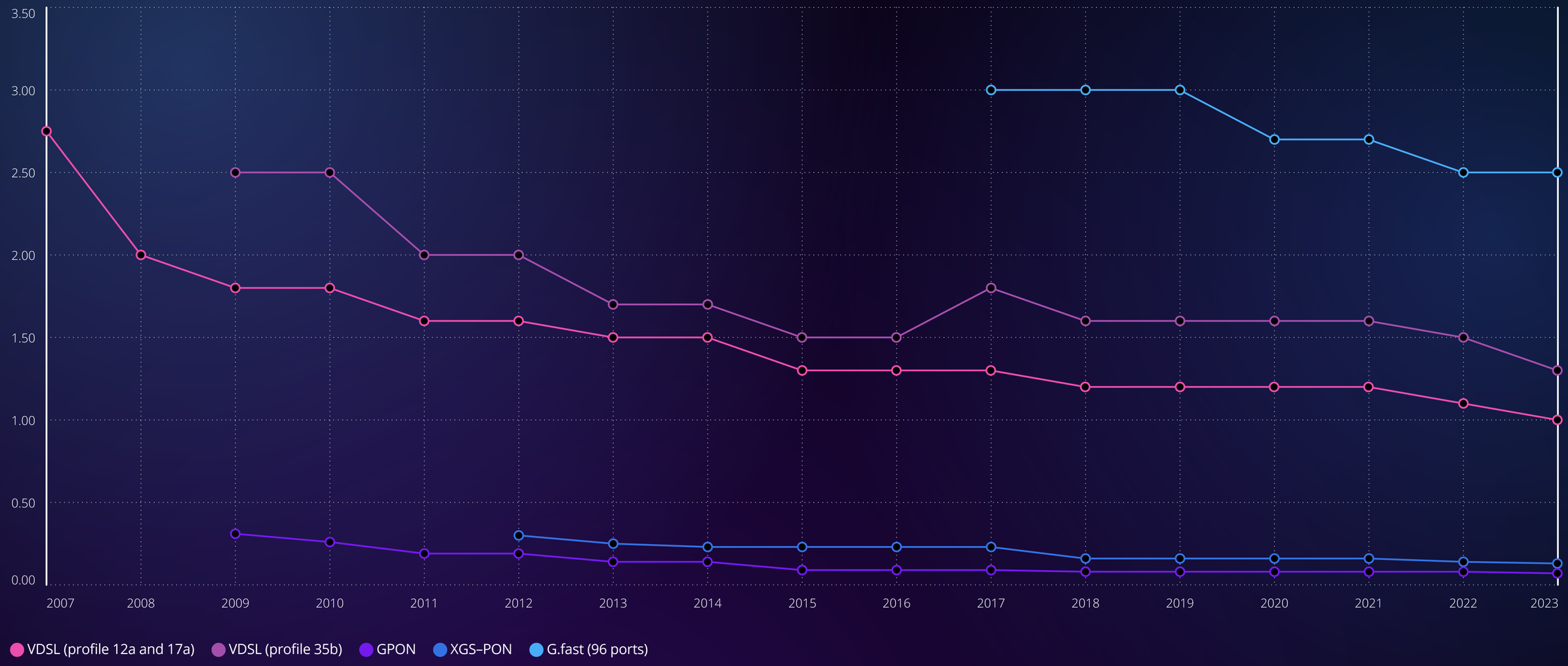
PON networks have a crucial role to play in helping operators meet sustainability goals and offer significant power consumption benefits versus alternative broadband infrastructures for equipment placed at the node. Figure 9 shows the EU Code of Conduct power consumption targets per subscriber for broadband equipment (64 port ratio) for different technologies. PON technologies enjoy significant benefits compared to other wireline technologies, such as VDSL and Gfast. PON access networks also offer particularly noteworthy energy consumption benefits versus fixed wireless access alternatives.

Figure 8: How does PON fit into your organization's sustainability plans or goals?



SOURCE: OMDIA, OPERATOR SURVEY 2023

Figure 9: Code of Conduct targets for power consumption per subscriber by network equipment (Watts per sub)



SOURCE: OMDIA

As noted, there is growing momentum behind next generation PON migration and this can also help serve operators' sustainability objectives. While XGS-PON has slightly higher power consumption than GPON, XGS-PON delivers five times the bandwidth capacity (comparing the total of downstream and upstream bits), making the technology more energy-efficient (and cost-efficient) per gigabit. Similarly, 25G PON offers two and a half times the capacity of XGS-PON (comparing the total of downstream and upstream bits) at just 50% higher power consumption. 50G PON offers four times more capacity for 200% more power consumption. Operators should also be aware that different vendors' solutions will have differences in terms of power consumption. For instance, the use of OLT chipsets that are specifically designed to reduce power consumption will reduce overall PON OLT energy usage.

Aside from the lower power consumption of active equipment at the node PON based FTTP access offers several other related lower power consumption benefits. As discussed PON fiber networks can also be used by enterprises or for other applications such as mobile transport. In this way rather than running separate PON and point-to-point networks operators can benefit from the reduced power consumption of operating a single PON infrastructure. PON networks can also be used as an alternative to traditional Ethernet LAN networks for in-building connectivity, and these Passive Optical LAN deployments offer the potential for considerable energy savings.

PON is inherently a passive infrastructure meaning there is no power required in the last mile access network between the OLT and ONT. In comparison, cable networks have active components such as amplifiers in the last mile network and these add to power requirements. A further inherent benefit of PON networks is that the capacity upgrades to next generation PON technologies discussed earlier in this whitepaper do not require changes to the optical distribution network, creating indirect environmental benefits from the reduced need for additional network construction. A further related point for stakeholders to consider is that the choice of business model for running the FTTP network has consequences in terms of sustainability. With a single network offering wholesale access that is used by multiple retail service providers, there will be reduced energy consumption if the network uses just a single set of OLTs. Moreover, there will be lower overall carbon emissions than would be the case if multiple overlapping FTTP networks were to be built.

A further area of exploration is that, as so-called green choices become more mainstream for many consumers, operators could search for opportunities to market these credentials to their retail subscribers. From an enterprise perspective, these same credentials can play directly into companies' sustainability stories, showcasing their own individual momentum to support energy and cost savings goals, along with larger ESG initiatives within their organizations.

COST BENEFITS TO OPERATORS OF PON'S ENERGY EFFICIENCY

The energy efficiency of PON networks also has an important role to play in improving operators' bottom-line profitability. The scale of the opportunity is shown by the fact that the French telecommunications regulatory agency, ARCEP, estimates that energy consumption in France for fixed networks in 2022 was 110kWh per subscriber and that fixed access networks represented 20% of total telecoms network energy consumption. Across both fixed access and core networks, total fixed network energy consumption in France was 1.1TWh, which, given prevailing wholesale energy costs, meant operators spent around €302 million on energy for fixed

networks. The more widespread use of PON FTTP networks alongside the eventual decommissioning of copper networks therefore holds the promise of considerable energy savings for operators, not least because copper decommissioning will mean there are opportunities for operators to close down local exchange sites. In the case of France, the potential for further energy consumption and cost reductions is considerable since FTTP only accounted for 66% of total broadband subscriptions at the end of 2023. It should also be noted that some operators in France are moving towards renewable energy sources for powering their network, but the underlying goal should still be to utilize less power overall, for instance, due to the potential cost savings described above.

FTTP operators must design attractive retail offers

While FTTP offers considerable benefits for subscribers versus alternative broadband infrastructures (for example in terms of higher speeds and better reliability), fiber operators also need to be aware that the technology does not sell itself. An important component of the success of FTTP rollouts will be operators' ability to market attractive retail packages to end users. FTTP operators must meet the key goals of strong subscriber uptake and healthy ARPUs. Higher FTTP speeds can play an important role in boosting subscriber take up as well as ARPUs. As noted earlier in this whitepaper these benefits form part of the rationale for upgrades to next generation PON technologies.

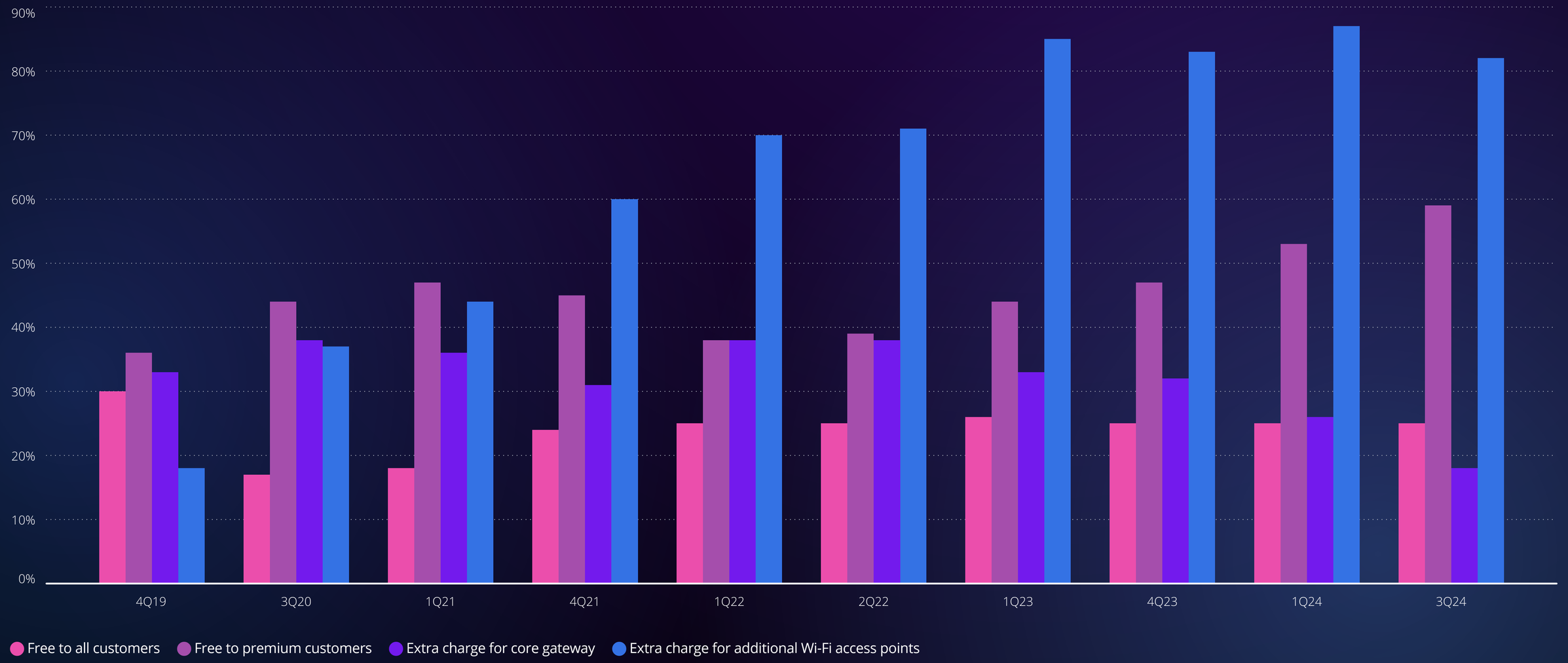
AN EMPHASIS ON A CPE CENTRIC RETAIL TARIFF STRATEGY CAN YIELD DIVIDENDS FOR OPERATORS

However, while offering higher speeds is an important part of any FTTP operator's retail tariff strategy, operators must also be sure to focus on other areas of their retail propositions. There are several reasons for this. FTTP access is becoming ever more prevalent, for example, as operators migrate existing copper-based DSL customers to FTTP and as some cable operators migrate away from DOCSIS based networks to FTTP. In addition, there has been, and continues to be, strong investment in FTTP from multiple sources all around the world. In practice these trends mean that there is a growing amount of FTTP overbuilding, whereby premises are covered by more than one FTTP network. In this sense there is a need for FTTP operators to do more to differentiate themselves from fiber competitors beyond just offering higher speeds. Moreover, the high costs of FTTP rollouts, which in some cases entail costs of hundreds of US dollars per home passed, mean that operators must try to find ways to increase ARPU.

In addition, as speeds increase and can increasingly meet the demands of end-users there is a growing focus among operators on the broader customer experience. This entails a greater emphasis on areas such as in-home Wi-Fi network coverage and performance as well as the technical characteristics of connections beyond just speed, such as latency. Overall, there is little sense in operators investing heavily in FTTP access networks to then be let down by poor quality in-home Wi-Fi performance. These factors are all pushing operators towards developing more CPE centric strategies which comprise various elements.

On a broad level operators could look to tier their retail tariffs based on the CPE offered. A higher-end CPE, for example, with the latest Wi-Fi generation could be reserved for the highest broadband tier to drive ARPU growth. Alternatively, an operator's advanced home gateway could be offered for free to all customers to maximize subscriber take up. Some operators have also used models where there is a separate charge for a core gateway, and ensuring this device offers

Figure 10: Advanced home gateway and Wi-Fi devices pricing strategy



SOURCE: OMDIA

users a good quality-of-experience helps justify such fees. Finally, a CPE centric strategy could also involve charging for additional Wi-Fi access points. Omdia data shows that operators are adopting a range of these different strategies (see Figure 10) which reflects the multiple options available for maximizing subscriber uptake and ARPU.

APPS DELIVERED THROUGH THE BROADBAND CPE OFFER A PROMISING OPPORTUNITY FOR DIFFERENTIATION AND ARPU GROWTH FOR FTTP OPERATORS

The starting point for a differentiated in-home offer is CPE that has embedded software to detect and mitigate connectivity problems in real-time. Band steering, client steering and seamless roaming need to be performed locally. Adding a cloud platform with automated Wi-Fi optimization brings the next level of user experience by adjusting the power levels to reduce the potential for interference, performing long-term channel optimization and so on. A further promising opportunity for operators is for apps delivered via the broadband CPE. Operators have multiple options to choose from. Such apps can be divided into different categories but will typically be associated with in-home Wi-Fi. Operators could examine apps that offer slicing of the in-home Wi-Fi network such that, for example, traffic associated with working from home or gaming is prioritized and that the network can react to ensure that the application works as it should.

In addition, there are other sorts of apps associated more broadly with in-home Wi-Fi such as connected home cybersecurity apps that promise protection across all devices connected to the Wi-Fi network, or Wi-Fi sensing apps whereby the Wi-Fi router and Wi-Fi connected devices can be used to detect movement within the home. Another area that has become increasingly popular is around parental controls and guest access. With parental controls parents can ensure their children use the internet responsibly by turning on and off Wi-Fi connectivity to different devices at different times.

Operators could benefit from such an app centric strategy because it could make their retail offers more attractive versus those of their competitors, thereby increasing customer acquisition and reducing churn. Importantly, however, all operators can benefit from an app centric strategy since it offers the opportunity for ARPU growth. For example, operators could include more apps in higher speed FTTP plans which will help encourage greater adoption of these more expensive tariffs. Operators could also offer these kinds of apps as a way to ensure subscribers continue to use operator provider CPE which is particularly important in markets where there is typically a separate monthly rental charge for such devices. However, to fully capitalize on this promising area, operators need to use a CPE vendor that promises openness and the ability to easily and quickly integrate apps from multiple different third-party vendors, for instance, with the use of containers on the CPE.

Appendix

About

Nokia

At Nokia, we create technology that helps the world act together.

As a trusted partner for critical networks, we are committed to innovation and technology leadership across mobile, fixed and cloud networks. We create value with intellectual property and long-term research, led by the award-winning Nokia Bell Labs.

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For more information on FTTP see:
https://www.nokia.com/networks/accelerate-into-gigabit-with-fiber

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Omdia

Omdia is a global technology research powerhouse, established following the merger of the research division of Informa Tech (Ovum, Heavy Reading, and Tractica) and the acquired IHS Markit technology research portfolio*.

We combine the expertise of more than 400 analysts across the entire technology spectrum, covering 150 markets. We publish over 3,000 research reports annually, reaching more than 14,000 subscribers, and cover thousands of technology, media, and telecommunications companies.

Our exhaustive intelligence and deep technology expertise enable us to uncover actionable insights that help our customers connect the dots in today's constantly evolving technology environment and empower them to improve their businesses – today and tomorrow.

*The majority of IHS Markit technology research products and solutions were acquired by Informa in August 2019 and are now part of Omdia.

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Stephen is a Senior Principal Analyst at Omdia and focuses on the fixed broadband access space from both supply and demand perspectives. His research examines fixed broadband related opportunities for operators and vendors.

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Jaimie's research areas include fiber, copper, cable, and fixed wireless access technologies. She has worked in the telecoms industry for over seven years. Jaimie's research findings and thought leadership have been published in key filings for prominent regulatory bodies, including the Federal Communications Commission (FCC) and the EU. She is based in southwestern Montana.

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