Copper switch-off

European experience and practical considerations

for FTTH Council Europe

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Executive summary

This study provides a summary of the findings of research conducted by WIK-Consult in Q3 2020 on the status of copper switch-off in 10 European countries, together with an analysis of the opportunities and challenges associated with migrating to modern fibre networks, and possible implications for policy-makers and regulators, in light of the implementation of the EU Electronic Communications Code[1] and revision of the EC Recommendations concerning "Next Generation Access". Findings are based on questionnaires and interviews with selected stakeholders, and build on an earlier study by WIK-Consult on copper switch-off which was completed in February 2019[2] and presented at the FTTH Council Europe conference in March 2019 in Amsterdam.[3]

Since our last study, further progress towards copper switch-off has been made in Estonia and Sweden, and concrete plans have been put in place to achieve copper switch-off in France and the Netherlands, alongside ambitious plans by KPN to deploy fibre more widely. However, the pace of migration has been slow in countries such as Spain and Portugal, even though fibre is widespread in these countries, while, countries such as Germany, Poland and the UK are unlikely to be in a position to migrate to fibre in the short term, because fibre deployment by the incumbent has been limited, and attention has only recently shifted towards the investments required.

In areas where FTTH has been widely deployed, considerable benefits could be gained by facilitating copper switch-off. These include reduced operational costs and an improved business case for operators investing in fibre, improved quality of service for customers and wider benefits to the environment and society, including reduced CO2 emissions in relation to the data consumed.[4]

Interviews conducted with NRAs and stakeholders suggest that there are a variety of factors holding back the migration to fibre and associated switch-off of the copper network, with different countries experiencing differing challenges. The reluctance of incumbents to invest in fibre access networks has been a key constraint in some cases, while challenges in persuading customers and access seekers to migrate has hampered progress in others. Regulatory factors including long notice periods for legacy network operators to switch off copper and associated wholesaling requirements for the closure of copper exchanges may have further contributed to delays and complexity in some countries which are otherwise ready to make the transition.

1 Article 81 EECC https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972&from=EN
2 Estonia, France, Germany, Italy, Netherlands, Poland, Portugal, Spain, Sweden and the United Kingdom.
3 See https://www.ftthcouncil.eu/documents/Reports/2019/Copper_switch-off_analysis_12032019_short.pdf. A more detailed presentation was given in July 2019 – see https://www.ftthcouncil.eu/home/latest-news/join-our-webinar-on-copper-switch-off-on-10-july!?news_id=3846&back=/events
4 A discussion of the energy efficiency of FTTH in comparison with copper and cable-based infrastructure is included in the WIK (2016) study Support for the Impact Assessment accompanying the Review of the EU Framework for electronic communications. One study found that FTTH networks would release 88% less CO2 than legacy technologies per Gigabit.

Based on our analysis of the key problems, underlying causes and good practice examples, as well as evidence from literature, we have identified the following areas where policy makers could take action to expedite the migration:

- Promoting infrastructure competition to incentivise fibre deployment by the incumbent and alternative investors. Relevant actions include ensuring that duct and pole access are made effectively available via SMP regulation and/or the BCRD and applying a light touch approach to full fibre regulation, at least in the early deployment phase;[5]
- Sending appropriate pricing signals to encourage customers and alternative operators to migrate from copper to fibre. Specifically, the price of copper and FTTC could be permitted to increase once fibre is widely available and can be supplied on a competitive basis;[6]
- Facilitating coalescence around a single FTTH network in areas where network duplication is not viable. This may entail the use of wholesale access by incumbent operators (e.g. where alternative wholesale only fibre networks have been deployed) or co-investment by incumbent operators with alternative infrastructure investors;[7]
- Facilitating exchange closure. Authorities could review in light of experiences in Estonia, Sweden and Australia, whether notice periods for copper exchange closure could be reduced e.g. to 18 months in areas of widespread fibre availability, and whether existing regulation or commercial opportunities are sufficient to support competition on fibre access;
- Informing customers of the benefits of fibre and supporting the switching process. Relevant authorities could ensure that customers are made aware of the difference between copper, TV-cable and fibre offers, by setting appropriate advertising standards. Switching processes between platforms could also be improved to enable customers to move to alternative operators deploying fibre; and
- Easing the process of phasing out legacy equipment. Operators switching their customer-base to fibre can support the migration through “plug and play” devices and processes that support analogue equipment and avoid site visits. Meanwhile, more complex business needs should be managed through direct contact.

There may be scope for member states and NRAs to update and clarify regulations concerning copper switch-off in the context of the transposition and application of

5 See for example WIK (2016) for the EC, Regulatory, in particular access, regimes for network investment in Europe, and WIK (2019) Prospective competition and deregulation https://www.ofcom.org.uk/__data/assets/pdf_file/0020/145046/b-group-wik-report-annex.pdf

6 See discussion and reference literature in section 3.2.2.

7 See WIK-Consult (2020) study for the BSG: Moving to a fibre-enabled UK: international experiences on barriers to gigabit adoption http://www.broadbanduk.org/wp-content/uploads/2020/06/WIK-report_BSG_02062020_final.pdf

provisions on “migration from legacy infrastructure” in the EU electronic communications Code.[8] There may also be a case to address these issues at EU level in any update made to Commission Recommendations concerning migration and the approach to access regulation and pricing of copper and VHC wholesale products.[9]

8 Article 81 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972&from=EN

9 Access regulation of NGA networks and migration are currently addressed in the 2010 Recommendation on NGA, while the relative pricing of copper and NGA is addressed in the 2013 Recommendation concerning cost methodologies and non-discrimination.

1 Introduction

In February 2019, WIK-Consult completed a study for the FTTH Council concerning the status of copper switch-off across 10 European markets[10] and associated benefits and challenges. The study was based upon questionnaires and follow-up interviews with the national regulatory authorities and the main operators in the countries. The first results were presented at the FTTH Council Europe conference in March 2019 in Amsterdam[11], and then in more detail at a Webinar on 10 July 2019[12]. In September and October 2020, we updated the research based on contacts in the 10 countries covered in the initial report and conducted additional interviews with stakeholders in countries which have ongoing initiatives to foster copper switch-off.

In this paper, we provide a synopsis of the findings of our benchmark regarding copper switch-off in Europe and put forward potential policy options to facilitate the migration from legacy networks to modern fibre technologies. Strategies to facilitate copper switch-off could be relevant as NRAs consider how to apply the provisions on migration from legacy infrastructure in the Electronic Communications Code.[13] We also discuss the case for updating existing guidelines on copper switch-off, which were last set out in the 2010 EC NGA Recommendation.

10 Estonia, France, Germany, Italy, Netherlands, Poland, Portugal, Spain, Sweden and the United Kingdom.

11 See https://www.ftthcouncil.eu/documents/Reports/2019/Copper_switch-off_analysis_12032019_short.pdf

12 See https://www.ftthcouncil.eu/home/latest-news/join-our-webinar-on-copper-switch-off-on-10-july!?news_id=3846&back=/events

13 Article 81 EECC https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972&from=EN

2 Progress towards copper and PSTN switch-off

In this chapter, we discuss the drivers and pre-conditions for copper switch-off, and outline progress made towards all-IP networks and copper switch-off in Europe and elsewhere.

2.1 What do we mean by copper switch-off?

Copper switch-off refers to the removal of legacy copper cables in the access network of traditional telecommunication operators and the shut down of the copper-based MDF[14] locations (local exchanges).

When a complete copper switch-off occurs, customers are migrated to alternative solutions such as fibre-to-the-home, TV-cable, mobile or fixed wireless access. In cases where operators have upgraded part of the access network to fibre (through FTTC/VDSL), a partial switch-off can occur, resulting in the closure of the legacy copper "feeder" network and the related LLU[15] services.

Copper switch-off often occurs on a regional basis, as operators seek to decommission legacy infrastructure in areas where FTTH or other solutions have been deployed. Complete switch-off can only occur once all customers can be served via an alternative technology.

Switching off copper means that voice traffic can no longer be routed via traditional PSTN[16] or ISDN[17] switches, and must be provided via Voice over IP.[18] Hence copper switch-off must be associated with PSTN switch-off and migration to IP. Over the last decade, most network operators in Europe have started to migrate their circuit switched network cores towards future proof IP-based Next Generation Networks (NGN). However, in some cases this migration to IP only applies to the core network, and operators use multi-service access nodes[19] (MSAN) to convert POTS[20]/ISDN signals in the last mile to digital IP-signals of the core network, thereby allowing end users to retain their legacy telephone equipment.[21]

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14 Main Distribution Frame.
15 Local Loop Unbundling; wholesale services enabling access seekers to use the physical local loop from the network operator to customer's homes to provide their own services.
16 Public Switched Telephony Networks.
17 Integrated Service Digital Network, a standard in PSTN networks.
18 While in theory one can convert the digital, IP-based voice signals of the fibre-based access network into analogue or ISDN transmission signals for the core network it is expensive and uneconomic to do so, because the core network switches have to be exchanged due to lack of supplier support already today or in the near future.
19 A MSAN converts POTS/ISDN to IP and can be located at central offices, street cabinets (FttC) or in the building of end-users (FttB). This is what we call Public Switched Telephony Network (PSTN) switch-off.
20 Plain Old Telephony Signals.
21 This decouples the exchange of the private customer equipment from public network infrastructure exchange, but requires dedicated terminal adaptors as CPEs.

The switch-off of the copper network and migration to FTTH will necessitate a shift towards “all-IP” and the associated switch-off of the PSTN network, and migration of any associated legacy terminal equipment at least in the mid term.

2.2 Progress towards copper switch-off

Despite the fact that fibre is now widely available in a number of European countries,[22] progress towards switching off the copper network has been slow. Out of 10 countries studied[23], Estonia has made the most progress towards copper switch–off (up to 80% of copper exchanges in 2020) followed by Sweden, which aims to shut down 54% of copper exchanges by the end of 2020.

However, within the last year, a number of other countries have set out ambitions to achieve copper switch-off. In December 2019, Orange France announced the start of the copper decommissioning in 2023 with the expectation that it would replace all of its copper exchanges by 2030[24].

KPN in the Netherlands has recently set targets to cease provisioning copper services for 2,4 mln customers by 2023,[25] while the UK incumbent Openreach, has set out plans for a phased migration, whereby legacy services would be withdrawn 5 years after the announcement of FTTP deployment at an exchange (see figure below).[26] In discussions involving the UK Government, target dates of between 2027-2030 have been discussed for the full switch-off of copper.[27] However, a complication is the significant role played by alternative fibre investors such as CityFibre in the UK.

22 Coverage data shows high levels of fibre availability in countries such as Spain, Portugal, Sweden, Denmark and a number of Eastern European countries.

23 Estonia, France, Germany, Italy, Netherlands, Poland, Portugal, Spain, Sweden and the United Kingdom

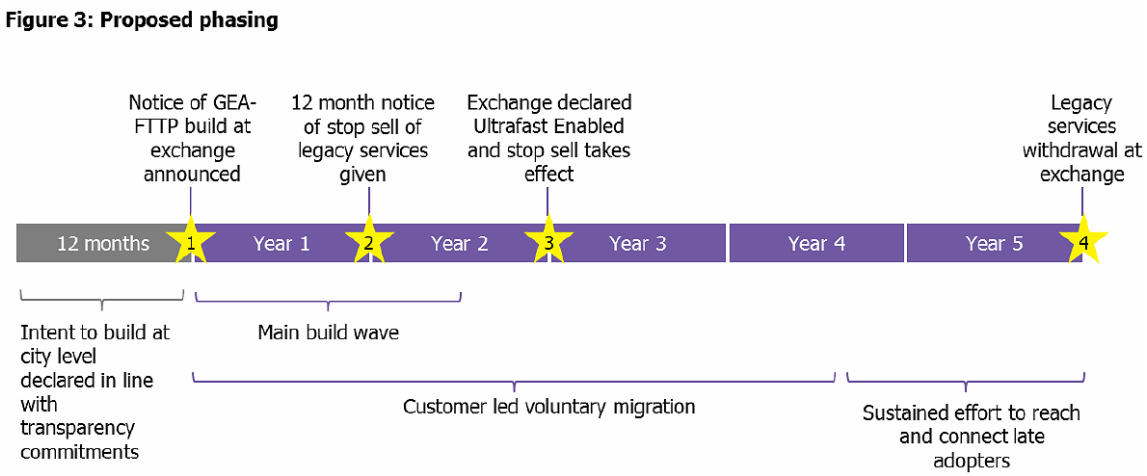
24 See https://www.commsupdate.com/articles/2019/12/06/orange-group-reveals-engage-2025-strategic-plan/?utm_source=CommsUpdate&utm_campaign=0797bef078-CommsUpdate+06+December+2019&utm_medium=email&utm_term=0_0688983330-0797bef078-8874781

25 https://www.commsupdate.com/articles/2020/02/25/kpn-aims-to-retire-copper-at-2-4m-addresses-by-early-2023/

26 https://www.ispreview.co.uk/index.php/2020/05/openreach-to-stop-selling-copper-phone-in-118-areas-go-fttp.html

27 See for example https://www.ispreview.co.uk/index.php/2019/09/bt-to-propose-full-fibre-move-and-copper-switch-off-by-2027.html#:~:text=Reports%20this%20morning%20claim%20that,Provided%20everybody%20agrees%20of%20course

Figure 1 Proposed phasing out of Openreach copper-based services in the UK



Source: Openreach

In Italy, the incumbent has made plans for copper switch-off in some areas, but the switch-off is associated with the deployment of FTTC, and only applies to copper between the street cabinet and MDF site. Only Germany has not yet set concrete targets for copper switch-off or to stop selling copper-based services.

The following table shows the status and planning for copper switch-off in the 10 countries covered by our analysis.

Table 1 Status copper switch-off (% copper exchanges)

	start	2018	2020	2021	2022	2023	2024	2025	2030
Estonia	2015	70%	80%						
Sweden	2009	42%	54%					98%	no target
Spain		2%	8%				14%	18%	
Italy		0%	0%			65%			
France	2023	0%	0%						100%
Netherlands	2023	0%	0%			40%			
UK	Tentative	0%	1.5%	19.5%	37.5%	55.5%	73.5%	90%	100%
Germany		0%	0%						
Poland		0%	0%						

Note: Figures in red are extrapolated. Switch-off in Italy is partial and refers to the feeder segment.

Table 2 Planned replacement technologies for copper

	Replacement technology
Estonia	FTTH (50% subs), fixed wireless (10%) FTTC (40%)
Sweden	FttH/Fixed wireless
Spain	FTTH
Portugal	FTTH/lesser HFC and FWA
Netherlands	FTTH
France	FTTH
Germany	No plans
Poland	No plans
UK	FttH

Source: WIK Consult

The context and drivers of copper switch-off in these countries differ, as shown in the following case studies, but overall, the following observations can be made;

- In Estonia and Sweden, the main motivation has been to achieve efficiencies in network operation. In Estonia, a key aim was to migrate the old ADSL copper network to a more cost effective and reliable fibre network, while in Sweden the focus was on migrating rural copper networks to mobile solutions while still maintaining copper networks in other areas.
- In Spain and Portugal, migration to fibre has been supported by intense competition in fibre-based broadband services and the popularity of ultrafast broadband and pay-TV multi-play offers. While migration in Portugal continues on a voluntary basis, the Spanish incumbent Telefonica has started a programme of forced migration. Although FTTH coverage in France is more limited than in Spain and Portugal, the French incumbent Orange has now established a goal for copper switch-off by 2030.
- Limited coverage of FTTH and the continued reliance on upgraded copper (FTTC) by the incumbent as well as access seekers meant that before 2019 copper, switch-off had been less relevant in Germany, Italy, the UK and the Netherlands. However, attitudes in the Netherlands and the UK towards switch-off have evolved as incumbents in those countries ramp up their fibre deployment plans. For example, incumbent KPN had been exploring copper switch-off in the area covered by the FTTH network, which was originally acquired from Reggefiber, and in 2019, KPN took a second step and announced that it would deploy more fibre outside the areas served by the Reggefiber network and plans to switch off 2.4m copper lines from early 2023 onwards.[28] Meanwhile, Openreach in the UK is

28 https://www.commsupdate.com/articles/2020/02/25/kpn-aims-to-retire-copper-at-2-4m-addresses-by-early-2023/

planning to expand its FTTP coverage to reach 3.2m rural premises,[29] and has proposed a £12bln investment programme with the aim of reaching 20m households with fibre by the mid-late 2020s.[30]

- Limited progress towards all-IP has also been an inhibiting factor for copper-switch-off in countries such as Poland and the UK, while France has also set an extended timeframe for PSTN switch-off. Conversely, PSTN switch-off is relatively well progressed in Germany and the Netherlands, which should facilitate copper switch-off once this process is pursued.

2.2.1 The Estonian case

Key indicators	
VoIP	100%
Copper exchanges switched off	70%
Copper switch-off target	60% HH end 2020
FTTH coverage % HH	51%
FTTH take-up % HH	40%
Target	All households have access to 100 Mbit/s by 2020

Estonia has made the most progress towards copper switch-off of all the countries analysed in our study.

Estonia's incumbent Telia, which operated the copper network, switched off the PSTN completely in July 2017 after a swift migration process of 2.5 years, starting from 2015. By the end of 2018, Telia had switched off 70% of its copper exchanges and it plans for all ADSL connections to be switched off by the end of 2020.

This does not mean that Telia is completely retiring its copper network. Copper access lines will still be used in less dense areas and Telia has been upgrading these areas towards FTTC VDSL vectoring since the beginning of 2018.

29 https://www.thinkbroadband.com/news/8797-openreach-announces-largest-yet-fttp-build-for-final-third-of-uk
30 https://www.computerweekly.com/news/252489081/Openreach-adds-67-locations-to-broadband-fibre-build-plan

Ultimately, the copper subscriber access lines will be replaced by access lines based on a mixture of fibre (50%), Fibre to the Curb (FttC) in combination with G.fast (40%) and Fixed Wireless Access (10%).

The swift copper switch-off in Estonia was facilitated by the swift prior PSTN switch-off, and was made more straightforward by the fact that there was very limited reliance on wholesale access to Telia's copper loops (less than 1% of all of Telia's active loops). In addition, Telia was strongly motivated to replace its old ADSL copper network as a result of the decreasing reliability and impact on customer satisfaction (see later description in 3.1.). Telia anticipated that they would benefit from lower fault rates and increased consumer satisfaction as well as considerable energy and space saving by switching off their ADSL2+ network.

A further benefit of the switch-off process was that regulatory barriers in Estonia were limited. The NRA permitted a relatively short notice period of 6 months for the closure of copper exchanges. This was however on the condition that alternative operators should have access to alternative wholesale services such as bitstream, fibre local loops or ducts at a similar price as the previous copper loops[31].

Other drivers for the copper switch-off in Estonia were:

- Backhaul fibre has been made widely available by the Government via the EstWin project. This project started in 2009 with the goal of providing backhaul fibre for operator nodes and mobile sites. Under this initiative, the Government aims by 2020 to have fibre deployed within 1.5km of 98% of network nodes. This non-profit backhaul network offers wholesale access on equal terms and is funded via EU funds (85%) as well as local providers;
- In 2017, the Estonian NRA established an online inventory to show where fixed line and mobile connectivity is offered (www.netikaart.ee). It obliged operators to share their data for this mapping. This gave the NRA and Ministry insights into where the whitespots (no offering) and grey spots (network but no fibre) are.
- In 2019 the Ministry started a project to roll out fibre access networks in white- and grey areas based on overhead energy poles (instead of ducts). Wholesale access was provided on equal terms and Telia was involved in the pilot programme.
- Attractive retail offers for customers; as of December 2018, VDSL at 100 Mbps was offered at 25€ per month and a symmetric 300 Mbps fibre connection at 33 € per month.

31 See Estonian Consumer Protection and Technical Regulatory Authority 16.06.2017 decision no 1-10/17-228 point 260 (9) and 285 (4) https://www.ttja.ee/sites/default/files/content-editors/Sideturg/II/lisa_1._t3a_turu_analuus_mte_maaramine_ja_kohustused_veebi.pdf (in Estonian language).

2.2.2 The Swedish case

Key indicators	
VoIP	54%
Copper exchanges switched off	54%
Copper switch-off target	No target
FTTH coverage % HH	93%
FTTH take-up % HH	66% (2019)
Target	98% to have access to Gigabit connectivity by 2025

Sweden's incumbent Telia initiated its copper switch-off programme as early in 2009[32] with a focus on migrating copper customers to wireless solutions or fibre (if available) in rural areas. By September 2020, 54% of of copper exchanges had been switched off. However, the main migration from the copper network to fibre outside rural areas has been driven by customer's own preferences. The Government's ambitious targets for Gigabit connectivity, 98% by 2025, also imply a further drive for migration from copper to fibre. However, one factor that may have deterred switch-off by the incumbent outside rural areas, is the widespread presence of municipal operators in Sweden, which have deployed fibre, often on a wholesale only basis. Thus, there are many areas in which the incumbent Telia may not have a fibre network of its own,[33] and switching off copper would require Telia to migrate customers to an alternative fibre network.

Although there are nominal requirements to provide 5 years notice for the closure of copper exchanges with co-located operators, switch-off has been facilitated by commercial agreements among the operators which shortened the period to 18 months, and by the recognition that mobile broadband solutions could offer an alternative to copper.

However, relatively strong wholesale obligations exist in areas served by fibre and where alternative operators are collocated. If fibre coverage is present then Telia is obliged to offer wholesale fibre access. Moreover, if access seekers are co-located at a copper MDF which is being switched off, they must be offered the ability to co-locate at the (replacing) fibre exchange and Telia is required to compensate the remaining depreciation costs related to the co-location of access seeker at the old copper exchange. These conditions, coupled with the fact that fibre in Sweden has been deployed not only by the incumbent,

32 S part of Telia's "Future networks" plan
33 See Swedish case study in WIK (2019) Competition and investment in Danish broadband markets https://ens.dk/sites/ens.dk/files/Tele/bilag_2_-_wiks_report_on_competition_and_investment_in_the_danish_broadband_market_non-confidential.pdf

but by alternative investors (municipalities) may have contributed to the fact that much of Sweden's copper switch-off has taken place in rural areas, where there is no fibre network available, and thus there is no obligation for Telia to provide an alternative wholesale service following copper switch-off.

According to Telia, it is essential that the migration process is predictable as regards process and timetable and that there is clear communication with regulatory authorities, municipalities, operators and customers, to make sure they understand what is happening and why. Furthermore, customers should be made aware that the new services are attractive and offer them more.

Telia reports that it aims to provide as smooth a migration process as possible for customers in order to maintain customer loyalty and has offered consumers help from a technician at home, free of charge, if they are not sure how to install the new equipment. Telia also offers fixed services via the mobile network at a lower price than was offered via ADSL and fixed telephony.

As regards voice, Telia has observed that customers prefer to switch to mobile solutions when migrating from copper PSTN-based voice, and this has meant there has been limited migration to fixed line VoIP when copper lines are decommissioned. However, these trends also mean that the switch-off of the PSTN network (which is being pursued only in the context of copper-switch-off), can be achieved without significant disruption.

2.2.3 The Spanish case

Key indicators	
VoIP	80% (2020)
Copper exchanges switched off	7,6% (2020)
Copper switch-off target	no target
FTTH coverage % HH	85% (2019)
FTTH take-up % HH	63% (2019)
Target	100% FTTH coverage by 2025 (dependant on FTTH roll-out)

Telefonica Spain has a very high FTTH coverage (85% of Households) and aims for 100% FTTH coverage by 2025, although this goal is dependent on the availability of public funds to support fibre deployment in very rural areas.[34] The alternative fibre

34 https://www.telefonica.com/en/web/press-office/-/telefonica-will-shut-down-one-copper-switchboard-a-day-until-2020

operator Orange is also actively migrating its copper-based (Telefonica LLU) customers to its own fibre network.

Despite the lack of a national targets for PSTN – and copper switch-off, copper switch-off in Spain is expected to take place steadily as fibre coverage and uptake are high.

In June 2018, Telefonica announced that it would shut down one copper switchboard each day until 2020.[35] NRA CNMC noted that this would amount to 653 exchanges by end 2020, representing only 7,5% of all exchanges. However, to date Telefonica has switched off 402 copper exchanges, representing 4,6% of all copper exchanges. In Q1 2019, CNMC announced that copper switch-off had accelerated and that by 2024 Telefonica would switch-off 1200 copper exchanges (representing around 15% of all copper exchanges)[36]

Telefonica reports that it started testing copper switch-off in the smaller exchanges which did not involve LLU customers, but that there will be an acceleration in the switch-off with more lines migrated in 2021 than in the whole period 2016-2020. The aim to achieve the switch-off of most copper exchanges by mid-2026. Standardised processes have been developed to enable wide-scale switch-off.

The Spanish NRA CNMC has identified a number of factors supporting the migration process from copper to fibre in Spain:

- The regulatory framework has been designed to incentivize investment in FTTH, not only by the incumbent, but also by alternative operators. Access to Telefonica's ducts and poles is available at cost-oriented rates. The NRA initially practiced forbearance on access to ultrafast broadband in the early years of deployment, leaving wholesale pricing for fibre (FTTH VULA) subject to economic replicability tests (rather than cost orientation) and later on regulated access only for less dense areas;
- Customers have shown demand and willingness to pay a premium for high value ultrafast broadband products, which are often bundled with pay-TV alongside voice and mobile connections. Indeed, benchmarks suggest that prices for triple play bundles including ultrafast broadband in Spain are above the EU average.[37] This has improved the business case for deployment of FTTH.
- For copper exchanges where there are no co-located wholesale parties, the guarantee period (for continued provision of copper-based services) is only 1 year. A copper exchange can be closed when more than 25% of end customers, connected to that exchange, are connected by alternative networks (e.g. fibre).

35 http://www.micgrup.com/en/telecommunication/microtelefono/blog/more-than-800-adsl-plants-closed-or-in-the-process-of-closure/28967.html
36 http://www.micgrup.com/en/telecommunication/microtelefono/blog/more-than-800-adsl-plants-closed-or-in-the-process-of-closure/28967.html
37 Empirica, TÜV Rheinland (2019): Fixed broadband prices in Europe, study prepared for the European Commission, downloadable at: https://ec.europa.eu/digital-single-market/en/news/fixed-broadband-prices-europe-2018.

However, there are also some aspects of the migration procedure that may be deterring switch-off. Specifically, if access seekers are using local loop unbundling then there is 6 months' notice and a 'guarantee period' for the old LLU service of 5 years. To mitigate this, CNMC recently proposed in a public consultation to decrease the 5 year notification period for Telefónica period to 2 years for copper local exchanges in which rival operators are co-located.[38] If this regulation is implemented, this would also mean that Telefonica might re-notify already notified exchanges for closure, with a view to shortening the timelines. This means that Telefónica may be able to significantly accelerate the shutdown of the copper network in areas where their fibre deployments have progressed extensively.

In Spain, PSTN switch-off is occurring alongside copper switch-off, as the phone service in the new FTTH network makes use of VoIP. VoIP is also commonly provided in the context of broadband bundles. According CNMC, as of September 2020 almost 80% of Telefónica's lines use VoIP. Alternative operators have also been making the transition to VoIP for customers relying on copper. For example, Orange Spain reported that 30% of its copper subscribers have been migrated to VoIP (and 75% of all its customers, including FTTH).

2.2.4 The Portuguese case

Key indicators	
VoIP	Around 60%
FTTH coverage % HH	>90%
FTTH take-up % HH	>50% (2019)
Target	90% FttH/B coverage in 2020

Similar to Spain, Portugal has a high FTTH footprint; Incumbent Altice Portugal had passed 76% of households by October 2018 and plans to achieve 90% FTTH coverage in 2020 reaching 85.3 million homes passed. The take-up rate of FTTH is comparable with Spain and above 50% (IDATE 2019).

Although the conditions would suggest that Portugal should be a strong candidate for copper switch-off, the process has been gradual and primarily customer-led thus far.

38 CNMC public consultation of 17 November 2020 on regulation of wholesale broadband markets, ANME/DTSA/002/20/M3-2014, see https://www.cnmc.es/novedades/2020-11-17-la-cnmc-lanza-la-consulta-publica-sobre-la-regulacion-de-los-mercados, page 99.

An early (2016) presentation by PT[39] suggested that there are no interim copper switch-off milestones; rather it is a gradual process, starting with PSTN/ISDN optimization (PSTN transformation plan and Product portfolio update to IP), and only moving later to network reorganisation (POP reorganisation).

Figure 2 Network simplification approach Portugal Telecom

However, PT has in practice ceased marketing copper solutions where fibre is available, and is supporting new, more attractive, solutions and packages to drive customer's migration to VoIP. In February 2019, Altice Portugal announced that it would stop marketing fixed voice services over its copper network to new customers. [40] Moreover, in October 2019, the CEO of Altice Portugal reported that the company has started to pilot switch-off in districts within 6 Portuguese municipalities that are 100% covered with fibre.[41]

One factor that will support PSTN switch-off in Portugal is the advanced state of migration towards all-IP. Voice services in bundles (which predominate in Portugal) were from the outset based on the NGN, and therefore there is no need to migrate these voice services to IP. As of 2018, 44% of the subscriber access lines were based on VoIP and the target date for PSTN switch-off is 2020.

However, the regulatory regime may have contributed to a more gradual switch-off. The incumbent was obliged to provide 5 years notice period to other operators when planning to deactivate MDFs, local switches or access/Interconnection points. This was reduced to 3 years in cases where an equivalent wholesale product (to copper wholesale) is available,

39 Alveirinho, L. (2016): Portugal Telecom, An All-Fiber Company In An All-Fiber Country, downloadable at: https://www.digiworldsummit.com/wp-content/uploads/2016/11/DWS16_Luis_ALVEIRINHO_Portugal_Telecom.pdf
40 https://www.commsupdate.com/articles/2019/02/13/meo-stops-marketing-copper-voice-services/
41 https://techblog.comsoc.org/tag/altice-portugal/

but this period is still longer than that provided in some of the other countries benchmarked, and this process has not yet been activated, to our understanding.

2.2.5 Other countries

With the exception of France and the Netherlands, no concrete plans have been made for copper switch-off in the remaining countries covered by the study. Barriers identified in our research including:

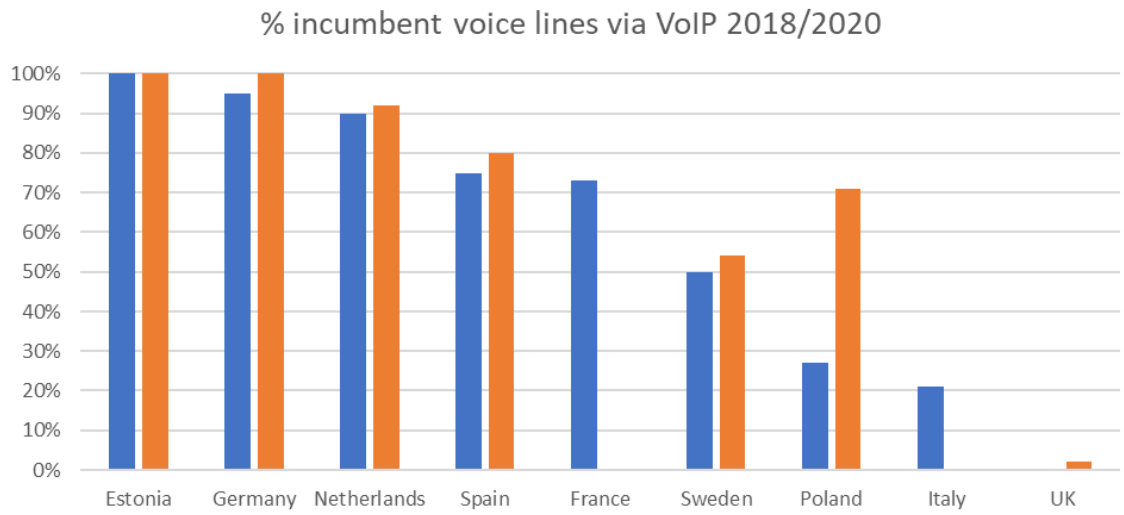
- Limited FTTH roll-out by the incumbent. This is especially an issue in Germany and Italy due to the incumbent focus on upgrading copper to FTTC/VDSL, and until recently also applied in the UK and NL;
- High usage of copper LLU. Although LLU take-up has been in decline, it remains significant in the UK, Germany, France, Spain and to a lesser extent the Netherlands. Reliance on copper-based access may impede switch-off especially in countries where there are strict conditions for closing exchanges with co-located operators. In some cases, significant differences in pricing between FTTC and FTTH wholesale offers, may also deter access seekers from migrating; and
- Long notice periods, strict wholesaling conditions, or lack of clarity on the rules for network operators to switch-off exchanges. For example, notice periods of 5 years to shut down copper exchanges (and similar periods for PSTN switch-off) may have contributed to delays in the switch-off process in France and Spain.
- Meanwhile, in the UK, Ofcom has made a proposal for a process which would begin at the end of 2020; first Openreach will be allowed to stop selling copper-based wholesale services once 75% of premises connected to a copper exchange are covered with ultrafast broadband. After this coverage is increased to 100%, there will be a further 2 years before the pricing regime applicable for copper-based wholesale access is transferred to fibre-based access. Once these steps have been completed, the process of closing copper exchanges can start including forced migration of wholesale customers. However, no rules have yet been established for these processes. A challenge seems to be to define exemptions to the rules as some premises are difficult to reach with ultrafast broadband.

2.3 PSTN switch-off

As described above, the transition from PSTN to all-IP is a pre-condition for copper switch-off (or should be done simultaneously). PSTN switch-off has been directly linked with copper switch-off in Italy, Sweden and Spain, and directly proceeded copper switch-off in Estonia. However, in other countries, including the UK, Germany, the Netherlands and France, PSTN switch-off has been pursued independently of copper switch-off.

The following chart shows the status of the migration of incumbent voice customers towards VoIP in the reviewed countries for 2018 and 2020.

Figure 3 Status PSTN switch-off incumbents



Source: WIK Consult

By Q3 2020, full transition to VoIP with PSTN switch-off had occurred in Estonia and Germany, with near full transition in the Netherlands. However, in contrast, there is limited VoIP in the UK except for new build/FTTH and some business premises. Italy and Poland also start from a low base of VoIP lines.

The following table indicates the interim status and in green the targetted end time of the PSTN switch-off.

Table 3 PSTN switch-off status (% voice lines)

		% incumbent voice lines provided through VoIP										
	start	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Estonia				100%								
Germany	2013		50%		95%		100%					
NL	2006		85%			92%		100%				
Spain	2009		20%		75%		80%		100%			
France					73%					>97%		
Poland					27%		71%					100%
UK					0%		2%	20%		60%	80%	100%
Sweden					50%		54%					98%
Italy	2012				21%					>65%		

Source: WIK Consult

The swift migration to IP in Estonia (2015-2017[42]) was based on an approach of making the migration as convenient as possible and by avoiding site visits with solutions which enabled site simulation. Telia Estonia identified therefore 3 key solutions:

1. The installation of a 'plug and play ready' broadband router with a POTS port. The end customer could install this new router by him/her self and plug its existing equipment in the POTS port.
2. The installation of a gateway solution in the exchange, which enabled site simulating, which avoided that Telia technicians had to schedule time consuming and intruding house visits.
3. For existing business customers using ISDN connections and equipment, a dedicated approach was defined, under which each site was inventarised and specific solutions were found to support the migration to IP. This solution required the longest timepath.

As explained, the main driver for Telia in Estonia to decommission its ADSL network was diminishing expertise and increasing fault rates and hence decreasing customer satisfaction. Another key driver for the migration to IP (and subsequent copper switch-off) was to achieve reduced operational expenses (OPEX) due to simplified and more concentrated network design with modern IP switches, which are easier to manage and for which expertise is more readily available. A similar rationale can be seen for PSTN switch-off in Germany, France, Poland, the Netherlands and UK. However, the process in these countries has been slower, and has not always been straightforward.

Although it has now finally been achieved, PSTN switch-off in Germany was delayed beyond the initial target of 2018. The process was pursued in incremental steps. DT firstly ceased selling POTS/ISDN products and replaced them with VoIP products, which had previously been bundled with all data access upgrades. Thereafter, it addressed all POTS/ISDN customers through active marketing, followed by notice that it would apply forced migration by terminating all contracts running out of term. NRA BNetzA moderated the process by initiating round tables involving private network equipment suppliers and specialist PSTN/ISDN-based applications (such as remote supervision and control, emergency call systems for elevators and disabled and the elderly, point of sales terminals, …), thus offering test beds to find alternative technical solutions. While the competitors promised to operate their PSTN/ISDN network up to 2022 most customers of DT finally accepted the need to update their private equipment.

During the course of the migration, DT also decided to implement PSTN/ISDN MSANs to facilitate a smoother migration, thus offering PSTN/ISDN copper access at least for a minority of lines. Some MSANs are located in the FTTC cabinets, but many are sited in local exchanges because copper switch-off was considered of less importance than

42 In that process it switched-off its ASDL2+ / ISDN technology, including 300 old telephone systems and 130 exchanges.

PSTN switch-off. This approach was also chosen in those areas where NGA (FTTC) roll out was considered too costly or was not expected to be deployed in the short term. As a result of these measures, PSTN switch-off has been decoupled from copper switch-off.

In the Netherlands, incumbent KPN started the process of PSTN switch-off in 2007, but has still not achieved 100%, most likely due to the voluntary process which has not yet addressed reluctant customers using legacy PSTN/ISDN equipment. In 2019, the Dutch incumbent KPN started trials in six pilot areas, in which KPN would test the migration to IP to gather more experience about complex technical issues and identify solutions.

In France, notice periods of 5 years and customer reluctance may also have determined the gradual pace of PSTN switch-off. Orange announced that from the end of 2018, it would cease to market residential and business PSTN and ISDN connections. Orange also notified the market in 2018 that PSTN will be switched-off in 7 regions starting end of 2023.

A critical barrier in the UK has been the pricing structure for "shared access" and VULA, which encouraged wholesale access seekers and end-users to continue to rely on subscriptions to a PSTN line alongside their broadband access connections. Nearly all telephone lines in the UK remain analogue. Following a consultation initiated by BT, Ofcom published a statement in February 2019 on the "future of fixed telephone services",[43] paving the way towards the all-IP transition. However, the process is still expected to take time, with BT withdrawing the Wholesale Line Rental products that rely on the BT PSTN network only in 2025.[44]

In Spain the PSTN switch-off is linked to the commercial development and take up of new fibre-based services. Telefonica Spain had migrated 80% of its voice lines to IP by the end of 2020 and plans for 100% in 2022. Alternative operator Orange Spain, also managing an (access-based) copper and a fibre network, already switched off its PSTN exchanges completely by 2018 and reports that 30% of its existing copper-based customers have VoIP and 75% of its total customer base (copper and fibre-based).

Notwithstanding the lengthy processes, most of the countries analysed have plans in place to migrate to all-IP networks and switch off the PSTN network by 2025. This should facilitate the copper switch-off process in countries, which have not yet taken this step. However, experience suggests that significant efforts will be needed by the operators (as well as regulators) concerned to ensure a smooth and on-time transition.

PSTN/ISDN switch-off is a prerequisite for copper switch-off, because investing into the conversion of IP-based broadband access network transmission into PSTN/ISDN core network signals is expensive and only short term. Conversely; first migrating the core network towards IP and then converting PSTN/ISDN signals into IP signals while

43 https://www.ofcom.org.uk/__data/assets/pdf_file/0032/137966/future-fixed-telephone-services.pdf
44 https://www.openreach.co.uk/orpg/home/products/wlrwithdrawal/wlrwithdrawal.do

changing the access network technology gradually, decouples the core network technology from the access network and the related long lasting copper switch-off and is therefore more future-proof and flexible, especially for business.

2.4 Europe's progress compared with elsewhere

Although we are aware of extensive copper switch-off occurring in smaller jurisdictions such as Jersey,[45] we are not aware of any large-scale projects in countries which are planning a full migration from copper to fibre. However, progress is being made, most notably in Australia, where migration is being driven by the nationalised broadband network.

In Australia, copper switch-off began in 2014 in conjunction with the deployment of the National Broadband Network (NBN), and acquisition by the NBN Co of Telstra's copper and cable network. Customers in "NBN ready" areas, have 18 months' notice to switch to the NBN, before the legacy infrastructure is switched off. The switch-off will not however be to full fibre. The planned technology mix is 17% FTTH, 48% FTTN/B, 27% HFC, 8% fixed wireless and satellite.

Meanwhile, in New Zealand, there were plans to allow operators to start withdrawing services in "fibre-ready" areas from January 2020. Chorus, the largest of the network providers in New Zealand, noted that in December 2019, fibre will be available to more than 75% of households, extending to 87% at the end of 2021. Chorus notes that while there will not be a "switch-off date", it is considering a gradual phase-out of copper, street-by-street and then town by town.[46]

In America, in October 2018, Verizon announced that it would phase out copper for FTTH in parts of 6 US states, and in 2019 extended its request to ask to retire copper networks throughout its service territory in those states.[47] In the US, copper switch-off is subject to very light touch regulation. In 2015, the FCC issued an order which permits providers such as Verizon to switch from copper to fibre without FCC approval as long as that change did not "discontinue, reduce or impair the services provided". The provider was also required to provide 90 days' notice to residential customers and 180 days' notice for businesses. However, in 2017 these rules were relaxed, and as of August 2018, providers such as Verizon have been able to transition customers from copper to fibre by providing notice to the FCC, rather than to the customers themselves.[48] Customers are migrated by a technician, with no change to voice prices and a special offer for fibre-based broadband.

45 See presentation of Jersey Telecom's copper switch-off plans at https://www.wik.org/fileadmin/Konferenzbeitraege/2019/Gigabit_society/McDermott_Gigabit_Society_Copper_Switch-off_151019.pdf
46 https://www.chorus.co.nz/copper-network
47 https://potsandpansbyccg.com/2019/04/08/verizon-to-retire-copper/
48 https://www.fairfaxcounty.gov/cableconsumer/cable/verizons-migration-from-copper-to-fiber-aug-2016

In October 2020, US network operator AT&T confirmed that it had stopped marketing its legacy DSL service from 1 October onwards. According to their Q2 2020 figures, AT&T still has 3,4% of its residential subscribers on DSL and the remaining portion on IP-based fibre services. At the same time AT&T announced that they would phase out outdated services including DSL and that customers, where possible, would be upgraded to their fibre network.[49] It should be noted however that AT&T's fibre deployment includes a significant proportion of FTTC/VDSL. According to the telco's 2Q20 report, AT&T's 'Entertainment' Group' (i.e. residential unit) served 13.944 million subscribers at end-June 2020. Of this figure, 469,000 still utilised DSL networks. At that date, 4.321 million customers used 'IP-Fiber' (i.e. fibre-to-the-home [FTTH]) technology, while 9.154 million users were connected via 'IP-Non Fiber' (i.e. fibre-to-the-node [FTTN]) platforms. In addition, the telco serves more than a million B2B subscribers via unspecified platforms.

In the wake of AT&T's announcement, mobile competitor T-mobile in the US has positioned its LTE-based Fixed Wireless Access solution as alternative to the existing DSL-based broadband customers of AT&T,[50] noting that AT&T's FTTP technology was not widely available within its fixed network footprint, and that coverage of the technology was especially limited in rural areas.

It should be noted that, similar to Europe, no concrete "end-dates" have been set for a full migration to FTTH in the international jurisdictions which we examined. However, there are examples of forced migration occurring within shorter timeframes than have been permitted in some European countries. For example, the 18 month notification period in Australia is short compared with the 3-5 years provided in some European countries, although it appears generous when compared with the 1 year or even 6 month notice periods provided in countries such as Poland, Germany and Estonia. The US regime provides even less notice than that provided in Australia and Europe.

49 Commsupdate, 6 October 2020, https://www.commsupdate.com/articles/2020/10/06/att-stopped-selling-dsl-plans-on-1-october/?utm_source=CommsUpdate&utm_campaign=03488c01a2-CommsUpdate+06+October+2020&utm_medium=email&utm_term=0_0688983330-03488c01a2-8874781

50 Telecoms-com, 9 October 2020, https://telecoms.com/506850/t-mobile-us-pounces-on-atts-dsl-pr-gaffe-with-ramped-up-fwa-service/

3 Benefits and challenges

3.1 Benefits to operators, consumers and society at large

As well as bringing higher bandwidths and the availability of new services and applications to consumers and businesses, fibre-based broadband brings benefits to operators and has a number of positive impacts on society at large. In this section, we highlight a number of these benefits, based on literature, and interviews conducted in the context of our benchmarking study.

Below we describe some of these benefits based on literature and experience from the countries studied.

3.1.1 Benefits to operators

For operators, the migration to IP and the eventual switch-off completely or partly of its copper network, is mainly driven by four factors:

- Reduced operational expenses
- Market demand for higher bandwidth and increased quality
- Higher take-up to support the FTTH business case
- Easier and faster development of new services

We consider each of these factors in turn.

Reduced operational expenses

Modern fibre-based networks require less maintenance but also less energy due to a significant reduction of transmission losses when using fibre instead of copper. Consequently, operators deploying fibre can benefit from a reduction in the number of network nodes and less equipment. In addition, operators can benefit from the sale of space previously occupied by copper exchanges, often in highly valued urban areas.

All network operators interviewed for the study mentioned the potential for operational network savings. In the context of its announced switch-off of copper exchanges, Telefonica observed[51] that a fibre PoP[52] covers the equivalent number of subscriber access lines of 4 copper switches. In addition, it noted that the access technology equipment for fibre occupies only 15% of the space occupied by the previous copper related equipment. In total, Telefonica estimated that switching-off its copper network and

51 https://www.telefonica.com/en/web/press-office/-/telefonica-will-shut-down-one-copper-switchboard-a-day-until-2020

52 Point of Presence, an access point from one place to the rest of the fiber network and thereby with the Internet.

migrating to fibre saves 60% of the energy costs. Telefonica has also noted that in additional to savings from reduced energy consumption, capital savings can also be unlocked through the resale value of copper and exchanges in city centres.

Similarly, the US operator Verizon has noted that overall, operating a fibre network is 60% cheaper compared to operating a copper network due to savings in required buildings (60-80%), energy (40-60%) and maintenance (40-60%). Furthermore, it noted that fibre is 70-80% more reliable than copper.[53]

For Telia in Estonia, one of the main drivers in switching off copper in rural areas was the diminishing knowledge and expertise related to its old network (due to the retirement of engineers), the increasing number of faults and related decreasing customer satisfaction and hence increasing churn. Telia Sweden noted in this context that it was able to shift 100 engineers working on their copper network into working on their fibre network within a time period of 10 years. Another important benefit for Telia in Sweden is that switching off the rural copper network enabled it to dismantle thousands of poles. Although the poles had no resale value, the move helped to avoid significant amounts of operational expense and future replacement costs

Some (but not all) of the cost savings associated with copper switch-off can also be achieved via FTTC deployment and PSTN switch-off. For example, DT's strategy of deploying its BNG network architecture should allow a reduction in its active MDF network node locations by 90%, which would facilitate significant cost savings in service provisioning and operational cost.[54] Telecom Italia will also likely save costs with its partial switch-off to FTTC. However, these strategies do not achieve the same energy savings or quality and reliability improvements, as a migration to FTTH.

Fibre roll-out supports increasing market demand for more bandwidth and quality

Evolving consumer behaviour (watching streaming content, VoD, HD TV, home office etc.), and the increasing number of devices has driven demand for more bandwidth and higher quality from residential customers, to the extent that the average needs of consumers can in many cases no longer be satisfied with copper-based broadband. These requirements already applied to larger business sites, and have also become essential for smaller sites and home workers, as video communications, cloud computing and IOT increase the demand for connectivity.

In addition, the COVID-19 crisis has led to a step-change in the adoption of digital solutions. In many sectors digital processes have been implemented swiftly to enable at least some work processes to continue. Practices widely adopted include video-

53 https://www.lightreading.com/ethernet-ip/new-ip/verizon-saves-60--swapping-copper-for-fiber/d/d-id/715826

54 The concentration of the access network to 900 BNG locations should in theory permit DT to close most of its 8,000 local access nodes. However, it has not yet announced any intention to do so.

conferencing, online education, home office, video appointments with doctors and more. Video-conference and collaboration tools play a crucial role in this shift.

Furthermore, due to the temporary closures of 'brick and mortar' shops, there has been an accelerated shift towards e-commerce. As even the most reluctant customers become accustomed to online shopping, it may be that after the crisis, these trends towards digital commerce may persist.

This implies that digital infrastructures will gain even further importance as people and businesses, including government institutions rely on it more intensively.

Although it requires a major up-front investment, with fibre networks, operators can serve the requirements of residential and business customers in the years to come, and help to ward off challenges from technologies which may not have the same capabilities or which may not be as future-proof.

Copper switch-off can support the business case for fibre

Another important benefit associated with copper switch-off is that – by migrating customers from the historic infrastructure to the new fibre-based network – take-up is increased and the business case for fibre is strengthened. Take-up is a critical factor in supporting a positive business case for fibre, as fibre deployment is characterized by high upfront (sunk) costs associated with civil works and the purchase of passive and active equipment. For example, bottom-up cost models prepared by WIK indicate that a penetration rate of 40% or more may be required to support a positive business case, even in cities, and this penetration rate has to increase in less dense areas – implying that fibre in these areas may have the characteristic of a natural monopoly.

In this context, Portugal Telecom noted that switching-off copper networks and migrating existing customers to the (often already existing parallel) fibre networks of operators will improve their business case strongly and enable them to roll-out further in areas, which were previously not economically feasible. KPN highlighted similar benefits in the Netherlands for the overlay areas where they operate copper in parallel with the fibre network acquired from Reggefiber.

In cases where customers appreciate the value of very high capacity broadband, strategies to migrate customers from copper to fibre can also support operators in charging a premium for higher capacity services. This is a factor highlighted by Spanish NRA CNMC in supporting the business case for FTTH in Spain.

Orange France and Jersey Telecom have also used FTTH to provide traditional telephone services at the same price as those offered over the legacy infrastructure, supporting migration for those unwilling to upgrade to broadband and higher bandwidth services. This is possible in the context of a mixed portfolio that ascribes value based on the services customers receive.

IP-based networks enable easier development of services by operators

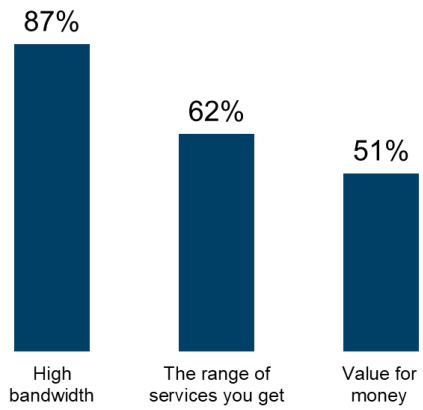
Portugal Telecom noted that IP-based networks support advanced multimedia services and enable new revenues, as well as supporting the deployment of 5G and enabling converged services to be developed in the near future. Other operators interviewed for the study also mentioned that migration to fibre-based infrastructure and IP services supported the faster and easier development of modern broadband bundles.

3.1.2 Benefits to consumers

Although interest and willingness to pay for fibre-based services varies in different countries, there is evidence that – once customers have subscribed to fibre – they experience a number of benefits.

In a representative survey of consumers in the fibre-rich Swedish market in 2017, it was found that much more FTTH customers were happy with their service compared with DSL customers (82% versus 50%)[55]. In addition, 87% of the FTTH users highlighted the high bandwidth as a benefit of FTTH-based services. Furthermore, the wider range of services and value for money were cited as advantage of the FTTH (see below graph).

Figure 4 Stated benefits of FTTH in Sweden

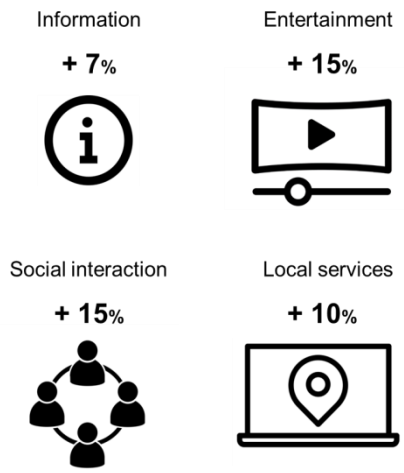


Source: WIK-Consult 2018 socio-economic impact of FTTH

The online survey conducted for WIK also highlights that users of FTTH tend to use online services more intensively as illustrated in the next graph.

55 See Arnold R., Kroon P., Tas S., Tenbrock S. (2018). The socio-economic impact of FTTH, https://www.wik.org/fileadmin/Studien/2018/FTTH_Council_report.pdf

Figure 5 Increased usage of online services by FTTH subscribers in Sweden



Source: WIK-Consult 2018 socio-economic impact of FTTH

FTTH users in Sweden were more likely to be online daily, were more active on the Internet than users in Germany (with a low FTTH coverage). Moreover, more than 30% of Swedes surveyed streamed all their music and video content online, which could indicate that the availability of high bandwidths associated with FTTH supports different usage models, although reverse causation cannot be ruled out.

3.1.3 Benefits to the economy, society and the environment

In addition to providing benefits to individual users, businesses and operators, a variety of literature indicates that the transition to very high bandwidths can also bring benefits to the wider society, economy and the environment[56]. To provide a few examples:

- Networks based on FTTH/B emit 88% less greenhouse gas emissions per gigabit compared to other access technologies[57]. In areas where FTTH has been widely deployed, considerable benefits could be gained by facilitating copper switch-off

56 See Arnold R., Kroon P., Tas S., Tenbrock S. (2018). The socio-economic impact of FTTH, https://www.wik.org/fileadmin/Studien/2018/FTTH_Council_report.pdf. See on reduced greenhouse emissions, Baliga, J., Ayre, R., Hinton, K., & Tucker, R. S. (2011). Energy consumption in wired and wireless access networks. IEEE Communications Magazine, 49(6), 70–77. doi:10.1109/MCOM.2011.5783987. See on possible savings by higher take-up of digital home services, Forzati, M. and C. Mattson (2014), FTTH-enabled digital home care – A study of economic gains, Department for Networking and Transmission, Acreo AB. See on increased start-ups in France, Source: Hasbi, M. (2017). Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence. See on higher GDP, Source: RVA (2011). Broadband Consumer Research. Sosa, D. (2015). Early Evidence Suggests Gigabit Broadband Drives GDP. See on increased employment, Source: Singer, H., Caves, K., & Koyfman, A. (2015). The Empirical Link Between Fibre-to-the-Premises Deployment and Employment: A Case Study in Canada.

57 Baliga, J., Ayre, R., Hinton, K., & Tucker, R. S. (2011). Energy consumption in wired and wireless access networks. IEEECommunications Magazine, 49(6), 70-77. doi:10.1109/MCOM.2011.5783987.

including reduced CO2 emissions. Full FTTP deployment can impact the rate of employment (in Canada, 2.9 %)[58] and increase the number of start-ups (5% in France)[59];

- FTTP can support the take-up of digital home and other social services which themselves provide significant savings. One study reviewing experience in Sweden and Finland estimated that small municipalities could achieve significant savings per capita due to the take-up rate of digital home services[60].

3.2 Challenges and solutions

Notwithstanding the many benefits that can be achieved through migrating from legacy to modern technologies, progress towards copper switch-off has been slow, as highlighted in section 2.2.

Interviews suggest that there are various reasons for the lack of progress. These fall into the following categories:

- Lack of incentives for the incumbent to migrate
- Lack of incentives for access seekers to migrate
- Unwillingness of customers to migrate; and
- Regulatory and legal barriers to migration

The following table provides an overview, based on interviews, of where the main challenges to copper switch-off have been observed in the countries studied (in yellow and particularly in red). We describe below how these challengers were dealt with in the countries leading copper switch-off in Europe and the role played by regulation in supporting the transition.

58 Singer, H., Caves, K., & Koyfman, A. (2015). The Empirical Link Between Fibre-to-the-Premises Deployment and Employment: A Case Study in Canada.
59 Hasbi, M. (2017). Impact of Very High-Speed Broadband on Local Economic Growth: Empirical Evidence.
60 Forzati, M. and C. Mattson (2014), FTTH-enabled digital home care – A study of economic gains, Department for Networking and Transmission, Acreo AB.

Table 4 Observed challenges to copper switch-off

	(Dis)incentives				Practical and regulatory challenges			
	Limited incumbent FTTH/B	Incumbent prefers not to access FTTH	Access seekers reluctant to switch	Customer reluctance	Challenges legacy equipment	Strict conditions to close exchange	Copper access obligations	Line powering obligations
Estonia								
France								
Germany								
Italy								
Netherlands								
Poland								
Portugal								
Spain								Settled 2009
Sweden								
UK						Not settled		Settled 2018

Source: WIK Consult

3.2.1 Limited incentives for the incumbent to invest in or access FTTH

A key challenge delaying migration towards fibre in certain countries such as Germany, Italy and the UK is that the incumbent has not deployed FTTH, but has instead implemented incremental upgrades to FTTC/VDSL. Sometimes with vectoring and G.fast, prolonging the lifetime of copper, even in areas where FTTH might be considered economically viable.

Various studies conducted by WIK[61] indicate that a key driver for the deployment of FTTH by the incumbent, as well as other players, is infrastructure competition – especially from alternative operators or investors which do not benefit from a legacy network of their own. It is in this context notable that, for various reasons, widespread infrastructure competition has been limited in the countries in which incumbents have been slow to deploy FTTH.

61 See for example WIK (2015) for Ofcom: Competition and investment: analysing the drivers of superfast broadband https://www.ofcom.org.uk/__data/assets/pdf_file/0022/76702/competition_and_investment_fixed.pdf, WIK (2016) for the European Commission: Access, in particular regulatory, regimes for network investment in Europe https://op.europa.eu/en/publication-detail/-/publication/c0da75d9-9a8c-11e6-9bca-01aa75ed71a1

In addition, the roll-out of 5G mobile networks has provided an added incentive for fibre deployment as mobile towers need to be connected by fibre connections and fibre backbone networks can be shared between fixed and mobile networks. This can be observed in the context of the combined fixed / mobile network deployment strategies pursued by operators.

Steps have since been taken by NRAs to address the shortfall in FTTH deployment in the countries where it has presented the greatest barrier to the Gigabit society. For example:

- In the UK, the NRA has placed a greater emphasis on operationalizing duct and pole access,[62] thereby supporting the potential for alternative operators such as Cityfibre to deploy fibre networks in competition with BT. Changes to the wholesale pricing regime which permit flexible pricing only for broadband at bandwidths over 40Mbit/s are also aimed at providing an incentive for BT to invest in higher bandwidth technologies;[63]
- In Italy, the authorities have facilitated the launch of a new entrant in the market; "Open Fiber", focused on the deployment of FTTH through a "wholesale only" model. Specifically, the public energy utility Enel and national investment fund Cassa Depositi e Prestiti took stakes in the newly formed company,[64] and authorities have put in place detailed rules concerning access to utility ducts and poles, which are used by Open Fiber to deploy infrastructure.[65]
- In Germany, in 2018 the national authorities moved to shift the focus of broadband state aid from subsidies provided for FTTC/VDSL towards subsidies for FTTH.[66] The prices for wholesale products of the incumbent based on FTTH are also ex post regulated, thus allowing for flexibility in pricing.

There is evidence already that stimuli from infrastructure competition and public funding may have supported a drive by incumbents to increase their FTTH footprint through investments or acquisition.

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62 Ofcom's latest review of the Physical Infrastructure market was concluded in 2019 and is available at https://www.ofcom.org.uk/__data/assets/pdf_file/0027/154593/volume-1-pimr-final-statement.pdf

63 Ofcom's 2018 Decision to impose cost orientation on VULA at bandwidths of up to 40Mbit/s while leaving higher bandwidths subject to flexible pricing is set out at https://www.ofcom.org.uk/__data/assets/pdf_file/0020/112475/wla-statement-vol-1.pdf

64 Theownership structure of Open Fiber is set out at https://openfiber.it/en/corporate/company/structure/

65 The rules applied under the broadband CRD are described in the WIK (2018) study for the EC "Implementation and monitoring of the broadband Cost Reduction Directive" https://ec.europa.eu/digital-single-market/en/news/study-implementation-and-monitoring-measures-under-broadband-cost-reduction-directive

66 https://www.breitbandausschreibungen.de/foerderprogs
https://atenekom.eu/wp-content/uploads/2018/11/181115_Leitfaden-zum-Bundesf%C3%B6rderprogramm.pdf

BT reached coverage of 2million UK premises with FTTP in 2019,[67] and have announced their intention to reach 20m UK premises by the mid-to-late 2020s. [68]

Telecom Italia and Fastweb have announced the creation of a wholesale network operator “Fibercop”, which will encompass the fibre network developed by FlashFiber (80% owned by TI and 20% by Fastweb) alongside TIM’s secondary network (the portion from street cabinets to customers’ homes). The company’s stated aim is to allow TIM, Fastweb and other operators to co-invest in fibre, with the aim of reaching 56% of premises by 2025.[69] If and where developments such as these result in an expanded FTTH footprint for incumbents, ownership of FTTH alongside copper will naturally incentivize incumbents to migrate customers to FTTH in the areas featuring overlapping networks.

However, a remaining challenge is how to support migration towards FTTH in areas where the incumbent does not control an existing FTTH network, and where indeed, it may not be viable for the incumbent to deploy an FTTH network in parallel with that of an alternative provider. In this case, it may be logical to consider the incumbent as a co-investor or potential purchaser of wholesale access from another player.

A challenge in this respect is that incumbent operators have historically often been reluctant to cede or share control of essential networks with others. There are indications that this may be changing. For example:

- In March 2019, Deutsche Telekom signed a joint venture with EWE for the deployment of 1.5 million FTTH lines[70] in Lower Saxony, North Rhine Westphalia and Bremen, which was agreed by the German Cartel Office in December 2019.[71];
- Portuguese incumbent MEO engaged in an infrastructure swap arrangement with Vodafone[72];
- Danish incumbent TDC signed an agreement to access the network of Eniig, a fibre utility, from 2018[73]; and

67 https://www.ispreview.co.uk/index.php/2019/12/interview-openreach-on-uk-fttp-rollout-competition-and-future-plans.html
68 https://www.ispreview.co.uk/index.php/2020/05/openreach-to-stop-selling-copper-phone-in-118-areas-go-fttp.html
69 https://www.lightreading.com/opticalip/fttx/tim-kkr-and-fastweb-agree-to-create-fibercop/d/d-id/763570
70 https://www.telekom.com/en/media/media-information/archive/deutsche-telekom-and-ewe-sign-contract-for-joint-venture-566330
71 https://www.bundeskartellamt.de/SharedDocs/Meldung/DE/Pressemitteilungen/2019/30_12_2019_DTAG-EWE.html
72 https://web3.cmvm.pt/english/sdi/emitentes/docs/FR51370.pdf
73 https://www.telecompaper.com/news/eniig-opens-up-network-to-yousee-tdc-business-services-from-2018--1219537

- Orange Poland has engaged in access and co-investment arrangements with other operators engaged in fibre deployment in Poland.[74]

However, many of these developments are recent, and it is unclear whether agreements such as these will be extended in reach and/or over time.

France provides an example of an effort to find a regulated solution to ensure the participation of the incumbent, alongside other operators in sharing infrastructure. In France, effectively all operators including the incumbent are required to construct fibre networks in a manner which allows passive access at points aggregating at least 1,000 households in less dense areas, where infrastructure competition is not considered to be viable. Terms, conditions and prices for such access have been established through guidelines and a series of disputes.

This system seems to have led, as envisaged, to a system of regional fibre network monopolies in France, each offering access on similar terms. However, it was applied before the widespread deployment of fibre, and its focus on regulating all operators could be considered disproportionate in cases where alternative operators have already deployed fibre without expectation of such regulation.

Nonetheless, it should be noted that provisions similar to those applied in France, could now in theory be applied elsewhere under new provisions on symmetric access that have been added to the EU Electronic Communications Code.[75]

The Code[76] also seeks to provide an incentive for SMP operators to engage in co-investment rather than seeking sole control over VHC infrastructure, as well as implying that NRAs should take commercial agreements into account when analyzing competition in the market.

3.2.2 Reluctance of access seekers to switch

Even in cases where the incumbent has deployed FTTH widely and wishes to migrate its customers from copper, in some countries there remains a challenge that alternative operators may prefer to rely on copper, rather than switching their customers to fibre. Relatively high levels of reliance on LLU for ADSL can be seen for example in the UK, France, Germany and Italy.

Key incentives for an alternative operator centre around the buy build options available on the copper versus fibre network, and the relative returns from each of these options

74 See for example https://www.capacitymedia.com/articles/3822190/orange-poland-signs-fibre-access-deal-with-inea
75 Article 61 EU Electronic Communications Code.
76 Articles 68 and 76

alongside the ability of alternative operators to make up-front investments versus relying on operational expenditure for the rental of access.

Literature suggests that, if there is a wide spread between the copper access price (LLU) and the price for renting access to an incumbent's fibre network, the alternative operator will remain on copper, impeding efforts by the incumbent to decommission its legacy infrastructure.[77] In addition, potential stranded investments associated with LLU and reduced flexibility from certain (active) fibre access options compared with copper unbundling may also deter alternative operators from migrating to fibre as well.

In the countries studied, as of the end of 2018, it is notable that, in nearly all cases, the wholesale access price for regulated access to FTTH was higher than the wholesale access price for LLU. Exceptions were in Estonia, where the prices are similar, and Poland, where the prices for copper-based access are said to be lower than those for fibre-based access.

Table 5 Regulatory pricing approaches for FTTH

	FTTH access obligations	Regulatory pricing approach FTTH vs copper	Regulated FTTH wholesale price vs copper
Estonia	Nationwide FTTH access	Cost-orientation based on top down historic costs both both copper and fibre. Pricing is similar	Same
France	Symmetric FTTH terminating segment obligations	Cost-orientation with risk adjustment on WACC for FTTH access. Long term pricing (IRU) offered alongside monthly rental	Higher €15/~€9.50 unbundled access. LLU set at € 9.51 for 2020 under assumption that copper will no longer be needed in 2025
Germany	Nationwide FTTH bitstream obligation on DT	FTTH bitstream not yet regulated in practice. NRA proposal for replicability test vs cost-orientation with mark-up for FTTC	Higher
Italy	Symmetric FTTH terminating segment + nationwide SMP FTTH bitstream + VULA on TI	Differentiated WACC for FTTH VULA vs FTTC VULA reflecting risk presumption	Higher
Netherlands	Despite withdrawal WFA Decision (nullified in court), ODF access, WBA and VULA is being offered at commercial basis. R	FTTH unbundling cost-based with risk premium on WACC vs NRA presumption of no premium for FTTC and copper	Higher ~€19.50 vs ~€8 unbundled access

77 For an overview see Bourreau et al (2013) Access regulation and the transition from copper to fiber networks in telecoms https://cadmus.eui.eu/bitstream/handle/1814/27597/RSCAS_2013_52.pdf?sequence=1

	FTTH access obligations	Regulatory pricing approach FTTH vs copper	Regulated FTTH wholesale price vs copper
Poland	SMP FTTH access (regional deregulation for BSA) alongside symmetric obligations	SMP copper and FTTH access on basis of cost-orientation, no risk premium	Lower ~€13 100Mbit/s vs ~€16 10Mbit/s
Portugal	No FTTH access obligations	Not relevant	Not relevant
Spain	Geographic VULA SMP access obligation on TF (~65% HH)	FTTH VULA pricing based on replicability test vs cost-orientation for copper	Higher
Sweden	Nationwide FTTH unbundling SMP access obligation on Telia	FTTH unbundling pricing based on replicability vs cost-orientation for FTTC/copper	Higher
UK	Nationwide FTTH VULA SMP access obligation on BT	FTTH VULA pricing based on replicability test vs cost-orientation for 40Mbit/s FTTC and copper	Higher

Source: WIK Consult

All things being equal, charging the same price for copper and fibre, or even a higher price for copper should create the right incentives for alternative operators to migrate. However, there are important considerations regarding the absolute level of fibre and copper prices and the interaction between the incentives of incumbents and alternative operators. If copper is priced at or above fibre levels, incumbents may have less incentive to invest in fibre. These incentives will be further reduced if fibre prices are “levelled down” to those more typical of copper, thereby reducing available returns from investing in fibre. Thus, in an environment in which access-based competition predominates (and is likely to continue to predominate) the timing of actions to adjust relative prices to foster migration is important. In an environment where incumbents have not yet invested in fibre or reached agreements to access fibre networks of others, the incentive mechanism that in theory should be most likely to trigger investment by incumbents and migration by altnets, is one in which there is initially a gap between copper and fibre prices, but where the incumbent is permitted to rapidly switch-off its copper network and transfer all access seekers to the (higher) fibre prices, or to raise copper prices to or above the level of fibre once fibre has been deployed.[78]

Another solution named “wedge pricing” developed in a 2016 paper developed by NERA,[79] would be, in the period prior to fibre deployment, to differentiate the price paid by access seekers (setting it equal to the forward-looking (fibre-relevant) FL_LRIC cost) and that paid by the incumbent (setting it equal to the short run incremental cost). The wholesale price paid to the incumbent would be increased to FL LRIC, after it had

78 This is the mechanism discussed in the WIK (2011) study Wholesale pricing, NGA take-up and competition https://pdfs.semanticscholar.org/2f6c/a27941fafc13f8320ac2264b9ecd01b886d7.pdf

79 https://www-origin1-vp.vodafone.com/content/dam/vodafone-images/public-policy/reports/pdf/balancing-incentives-for-the-migration-to-fibre-networks-310317.pdf

completed a widespread deployment of FTTH, thus rewarding its investment. This would send a build signal to the incumbent, while simultaneously ensuring that there is an incentive for access seekers and end-users to migrate.

The strategies described above could also be compatible with a strategy to encourage alternative operators to invest or co-invest in fibre and migrate copper customers onto their own networks rather than continuing to rely on wholesale access from the incumbent. In this scenario, experience from countries such as Spain and Portugal suggests that in addition to paying attention to relative pricing, other regulatory strategies may also be needed to stimulate investment from alternative operators.[80] These could include:

- Supporting the business case for alternative operators to invest in fibre. This may necessitate availability of access to ducts and poles and/or efforts to reduce the cost of and simplify civil works; and
- Limiting availability, at least in the short term, to wholesale access to fibre on the incumbent network to provide a window for alternative operators to invest and/or to reach commercial settlements for long term right of use to fibre

To support the incentive effects of the relative pricing of copper and fibre, there should preferably be a signal in advance that copper prices are likely to rise to match fibre prices in areas where fibre is widely available, and that barriers to switch-off will be reduced. Such a signal would indicate to the market as a whole that incumbents have the relevant incentives to make the transition to fibre, and that the lifetime of the copper network is likely to be limited, further encouraging alternative operators to take up the investment challenge, rather than remaining on the legacy copper network.

There are limited examples thus far of NRAs considering the incentive effects of relative pricing and switch-off signals in their regulatory strategies for mass-market broadband. However, one NRA which has been examining this approach is ARCEP. In its December 2017 Decision, setting LLU prices for 2018-2020, ARCEP noted that, in assessing pricing for copper, it had analysed the cost for an efficient operator to deploy a fibre network, and wished to reflect the results of that analysis in order to provide a long-term signal that pricing should reflect the cost of the future reference architecture. ARCEP also considered at that time, but chose not to pursue a geographically differentiated approach to pricing.[81] ARCEP has also provided the potential, under certain circumstances to reduce the timeframe for switch-off in fibred areas. However, timeframes remain constrained by the timing for PSTN switch-off,[82] and the accelerated provision for copper switch-off has not been triggered thus far. Discussions on potentially adapting the

80 See WIK (2019) Prospective competition and deregulation https://www.ofcom.org.uk/__data/assets/pdf_file/0020/145046/b-group-wik-report-annex.pdf

81 https://www.arcep.fr/uploads/tx_gsavis/17-1570.pdf

82 According to Orange, a 5 year timeframe has been provided for the switch-off of PSTN setting a limit on ambitions for copper switch-off.

conditions for PSTN and copper switch-off are ongoing with stakeholders and the regulatory authority.

The Swedish NRA has also set copper unbundling charges on the basis of a cost model which uses FTTH costs (and fixed wireless in rural areas) as a reference architecture.

Signals of a potential future approach towards mass-market copper in a fibre-rich environment can be seen in approaches taken to regulation of business copper in the UK and Austria. In both countries, the NRA concluded that legacy leased lines (low bandwidth/traditional interface), which are typically based on copper, should be deregulated, so that incumbents could manage the transition from legacy to more modern networks.[83] Moreover, in its comments on the Swedish market analysis for a newly identified "copper" segment of the wholesale local access market, the European Commission noted[84] that "should the [copper] market continue to shrink at the past rates, the Commission urges PTS to revisit its finding of SMP… and to deregulate the market ahead of the standard review period."

3.2.3 Customer reluctance / Legacy equipment

Reluctance from end-users to switch can be another significant barrier to achieving migration from copper to fibre. Switching barriers for customers can be affected by:

- Relative pricing of ADSL/FTTC products in comparison with FTTH/B;
- Satisfaction with ADSL-based offers (thereby seeing limited value in upgrading);
- Practical difficulties associated with switching from one product to another or from one platform to another; and/or
- Legacy equipment which is not supported by IP-based communications infrastructure.

For example, interviews conducted in the context of our study suggest that in France, customers are reluctant to migrate to fibre-based services due to the high quality of the DSL network and lower prices compared to fibre-based broadband. In other words, there was a perceived lack of imperative to switch. The intervention of a technician in the home was also not always welcome.

In Spain, making contact with owners of second homes and holiday residences was considered a challenge by interviewees.

83 The UK decision is included in Ofcom's 2019 market review of business connectivity markets https://www.ofcom.org.uk/__data/assets/pdf_file/0027/154593/volume-1-pimr-final-statement.pdf

84 https://circabc.europa.eu/sd/a/c04ce6b3-bed7-4838-8134-5dce237eb953/SE-2019-2216-2217-2218%20Adopted_EN.pdf

Meanwhile, in Poland, interviewees noted that reluctance to migrate to VoIP is present particularly amongst older customers, and may be linked to concerns about the replacement of legacy equipment including PSTN telephones and alarms.

Interviewees in nearly all countries agreed that business customers could often be more challenging to migrate than residential customers due to the extensive use by some businesses of legacy equipment such as PABX and ISDN connections, which in many cases still are the basis for their internal corporate network and call centres, too.

Indeed, the Estonian incumbent noted that the most significant challenge it had faced in its PSTN and copper switch-off programme was customer reluctance and the need not to risk losing revenues from fixed line customers, in an environment where mobile penetration is high and provided a potential alternative. Telia Estonia's strategy was to minimise disruption for customers by using 'plug and play' installation of new broadband routers with a POTS port to support legacy equipment and solutions in the DSLAM/ADSL (MSAN) subrack, which enabled site emulation and therefore removed the need for site visits. For business customers a case by case migration was planned, whereby the company reviewed for each business customer how the installed equipment could best be replaced or migrated.

As of 2019, KPN in the Netherlands had switched most of its PSTN customers to IP (93%), however it noted that the last segment of its customer base seemed reluctant to switch. Therefore, in 2018 KPN announced that it would conduct 6 pilot projects in which it would inventarise the specific technical issues with existing POTS/ISDN equipment and guide customers one by one through the migration.

Most of the challenges with legacy equipment are linked to PSTN switch-off, and thus countries which have settled these issues (or will settle these issues in the coming years) should be better placed to support customers in migrating to fibre when the copper network is switched off.

Relative pricing

The same considerations discussed for incentivizing migration by alternative operators also apply to end-users; End-user prices for copper and fibre that are closer together (or even higher for copper) should incentivize customers to switch.

To provide an illustration, the following table shows the relative monthly retail prices for broadband in the 10 countries considered. The first column displays prices in € for retail BB services with speeds below up to 20 mbps, the second column around 50 Mbps etc. The colours indicate per column (speed category) whether the prices are either on the lower (green) or on the higher side (orange).

Table 6 Overview of retail broadband prices in Europe Q1 2019

DL speed (Mbps)	<20	50	100	300	500	1000
Germany	29	31	33	37	54	
France	30		30	32	39	
Estonia	26	33	37	46	53	120
Spain		44		51		
Italy						48
Netherlands		48	62			
Poland			25	30	38	
Portugal	42		38			61
Sweden		43	38	44	47	67
UK	47	49	56			

Source: WIK Consult

The above table suggests that pricing in Sweden and Portugal, where some copper retail offers are priced at a higher level than those based on fibre, provide the greatest incentives for customer migration. The similarity of pricing between ADSL 20Mbit/s offers and services offering 100Mbit/s or more in France should also support migration, while in Spain copper-based retail offers are no longer actively marketed at all in areas served with fibre. On the other hand, pricing in the UK, Netherlands and Germany follows a tiered structure that appears to focus more on incentivizing upgrades to intermediate technologies such as FTTC/VDSL (coupled with vectoring in NL and Germany).

As regards creating appropriate price incentives for retail customers to switch, operators with both copper and fibre networks should have an incentive to adjust retail prices in this way. Thus, providing a framework in which all major operators are tied into the fibre future (e.g. through co-investment) is likely to provide a commercial environment that is conducive to migration. Alternatively, adjusting copper wholesale prices upwards in areas where there is comprehensive fibre coverage (and the potential for deployment, access or co-investment by those not owning the fibre), could achieve the same result.

Switching platforms

Technical challenges associated with switching from one platform to another (e.g. from the incumbent's copper network to a challenger fibre network) can be addressed through procedures to streamline switching, which govern for example, who should lead the switching process and penalties when switching is delayed. In December 2019, Ofcom issued a consultation on "fair treatment and easier switching for broadband and mobile customers" in which they require the customer's new broadband provider to lead the switch, and limit loss of service to one working day. Ofcom also proposes to prohibit account closure charges or notice periods beyond the switching date for residential customers switching their fixed services.[85]

85 https://www.ofcom.org.uk/__data/assets/pdf_file/0032/184757/consultation-proposals-to-implement-new-eecc.pdf

Labelling/transparency

As regards the value customers place on fibre, two issues can be distinguished. Firstly, customers may be unclear as to the difference between copper and fibre. This may particularly be the case if marketing messages have confused the two, thereby affecting customers' expectations on what "fibre" will deliver in terms of enhanced speed and quality. Secondly, even if clear as to the distinction, customers may not be convinced as to the need or value of fibre. Advertising standards authorities and NRAs have taken action in some countries to address the first concern. This is the subject of another study conducted by WIK-Consult for the FTTH Council Europe.[86] As regards the second issue, surveys suggest that customers which have experienced fibre, are on balance more satisfied with the service delivered,[87] and ultimately use the service more extensively.[88] Thus, even if there is initial reluctance amongst some customer groups, it seems reasonable to expect that strategies which encourage migration, at first voluntarily (e.g. through relative pricing and accurate labelling), and then on a mandatory basis, will ultimately deliver greater levels of customer satisfaction and recognition of the benefits of modern fibre technology.

3.2.4 Regulatory barriers to migration

Interviews conducted in the context of this study, suggest that the main barriers to copper switch-off do not stem directly from regulation on switch-off, but are rather associated with a lack of incentives to invest in fibre and customer reluctance to switching.

Nonetheless, specific regulatory conditions governing the closure of copper exchanges can have an important impact on the speed and ease of migration and switch-off.

Guidance currently in force on copper switch-off processes stems from the 2010 EC Next Generation Access Recommendation, which states that SMP (access) obligations in relation to Market 3a/b can be changed if agreement is reached between SMP operator and access seekers on an appropriate migration path. If there is no such agreement, SMP operator must inform alternative operators not shorter than 5 years in advance of any network changes and/or decommissioning.[89] This period may be less than 5 years if "fully equivalent access" is provided at the point of interconnection.

In line with these provisions, most regulators have set out notice periods for the closure of copper exchanges and wholesale access conditions that must be met as a pre-conditions for the closure of exchanges.

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86 See forthcoming WIK study on misleading fibre advertising due April 2020.
87 https://www.prysmiangroup.com/staticres/Nexst-2015-3/articles/new-studies-show-how-fibre-really-makes-a-difference.html
88 WIK-Consult 2018 socio-economic impact of FTTH.
89 Para 39, NGA Recommendation of 2010, EC, see https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010H0572&from=EN

The following table provides a summary of the notice periods and associated wholesale obligations in the 10 countries covered by our analysis.

Table 7 Notice periods and regulation on exchange closure

	Notice period for exchange closure	Wholesaling obligations linked to exchange closure
Estonia	6 months	None, but fibre wholesale access is available on similar conditions to copper wholesale access
France	5 years - shorter period may be requested for copper in "fibred" zones, but 5 years applies to PSTN switch-off	Wholesale offers must allow altnets to replicate „in an equivalent manner“ offers available on the copper network
Germany	1 year notice to withdraw LLU	Alternative wholesale offers must be made - in practice cabinet VULA, local bitstream
Italy	3 years if no LLU, 5 years if LLU - can be reduced to 3 if suitable wholesale	Technically and economically equivalent VULA guaranteed for 2 years after switch-off
Netherlands	Before: 3 years notice before end of life and 1 if suitable wholesale replacement. IN March 2020 nullification of NRA regulation due to incomplete evidence of joint market power KPN and VodafoneZiggo	Unbundled FTTH, VULA FTTH or WBA FTTH - KPN must offer different price model if scale is obstacle for access seekers
Poland	12 months	No specific wholesale requirements
Portugal	5 years or 3 if equivalent wholesale	Products "equivalent" to copper wholesale
Spain	5 years (LLU), 1 year (no LLU)	Exchange can only be closed when > 25% of customers are connected by alternative means (e.g. fibre). If there are alternative operators unbundling the loop, Telefónica must continue to provide this wholesale service for 5 years, with 6 months’ notice. If there are no alternative operators in the plant, the guarantee period is reduced to 1 year with 6 months’ notice.
Sweden	5 years for exchanges with co-located operators, but commercial agreements made with 18 month notice	No specific wholesale requirements
UK	No established rules	No established rules, but WLR obligation in place until 2020

Source: WIK Consult

A first noteworthy point is that whereas the conditions in Estonia and Poland[90] are relatively light (6 and 12 months respectively) with no specific associated wholesale requirements, much longer periods have been applied in many other countries.

90 Orange Poland (OPL) may close exchanges in line with the standard reference offer (Part II, chapter 2, point 2.4), which stipulates that OPL has to inform the NRA and marketparties, with 12 months’ notice of closing exchanges in relation to consolidation of TDM exchanges for the purpose of cost optimization.

5 years notice is typical, although this period can be shortened to between 1-3 years[91] for exchanges where there are no co-located operators (ES, SE, IT) and/or where suitable wholesale products are made available (PT, DE, IT, NL). Widespread coverage of alternative technologies in the relevant area is another condition that has been linked to switch-off in FR[92] and ES.[93]

Adequate notice periods are required to enable end-users to adapt their equipment and services, as well as ensuring that alternative operators relying on access can move to alternative solutions and are not left with stranded investments.

However, the time frames in many European countries are longer than those applying elsewhere in the world (e.g. Australia and the US) and conditions may have contributed to slower switch-off processes than may otherwise have occurred in countries with significant FTTH deployment such as France, Spain and Portugal. Meanwhile, in countries such as the UK, no process or timeframe has yet been established for copper switch-off.[94]

An additional question concerns whether "adequate wholesale access" implies that services should be offered at the former bandwidths at the same price over the new infrastructure as were available over the historic infrastructure, or whether currently available access to the NGA network, or opportunities for (co)investment by alternative operators provide sufficient scope to ensure that competition will be ensured in the post switch-off environment.

Some countries, including Spain, Poland, and Estonia have relied on standard NGA wholesale access (or self build), while others, including the Netherlands and Germany have set specific rules in place for the alternative wholesale products to be made available, including in some cases provisions on pricing.[95] France and Portugal go further in stating that the offers must allow alternative operators to replicate products which were made available on the copper network.

In July 2019, the Italian NRA AGCOM issued a resolution, which obliges TIM, in addition to pre-notifying switch-off, also to reach 100% NGA coverage and 60% NGA take up

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Alternative operators have thereafter 12 months to decide whether to give up providing their services, migrate to other exchanges or change the technology.

91 The Spanish NRA provided from the outset (2009), exceptions to the 5 year rule, allowing a notice period of 1 year for exchanges in which there were no unbundled operators.

92 Shorter periods for switch-off may be required in designated "fibre" zones, but extended notice periods continue to apply for PSTN switch-off.

93 Copper switch-off in Spain was initially linked with the condition that at least 25% of subscribers at the copper switch should have access to a connection which is not based on copper. This condition was lifted in 2016 as FTTH coverage of Telefonica was already very advanced (in 2016 above 30% of HH were already subscribed to FttH.

94 In the UK, exchange closure has not yet been explored in detail due to the limited availability of FTTH. However, discussions are now under way.

95 The Dutch NRA also noted that access seekers migrating from copper LLU to fibre unbundled access need time to reach a similar scale as they had on the copper network. Therefore, the NRA in the Netherlands obliged incumbent KPN to offer a different price model if scale is an obstacle for the access seeker.

before switching off a copper exchange.[96] This could be a hurdle for network operators to switch-off their copper networks. In addition, AGCOM also required that the use of fixed wireless access to achieve 100% NGA coverage should also be subject to prior approval.

It should be noted that more recent provisions on this subject in the 2018 European Electronic Communications Code, provides more flexibility on timing and the existence or nature of any regulated access than are implied by the 2010 NGA Recommendation. Specifically, the Code includes an obligation for SMP operators to notify the NRA in a timely manner of any migration plans and/or decommissioning. NRAs must ensure that "*the decommissioning process includes a transparent timetable and conditions, including an appropriate notice period for transition, and establishes the availability of alternative access products of at least comparable quality providing access to the upgraded network infrastructure substituting the replaced elements if necessary to safeguard competition and the rights of end-users..*"[97]

Thus, legislation that is in the process of being transposed at national level could support less onerous notice and wholesaling obligations than were implied by previous guidelines.

Other regulatory issues

Although notice periods and wholesale conditions for copper switch-off are the main regulatory requirements directly impacting switch-off, other regulatory requirements can also have the effect of impeding or delaying switch-off. These include requirements under the SMP or USO regimes to provide analogue wholesale and/or retail services such as wholesale line rental or analogue leased lines, or requirements for line-powering on telephone lines. Our assessment of regulatory conditions in the 10 countries considered suggests that line-powering requirements had generally been addressed (though entirely removing any such requirements and/or offering the option of battery back-up), and that few countries imposed obligations which would require the continued provision of analogue services. One exception is the UK, where WLR obligations continue to apply, but these are expected to be withdrawn.[98] Openreach has announced that new WLR supply will cease in 2023,[99] and is also working on a "naked VULA" product which would enable operators to cease purchasing WLR or LLU alongside VULA, as currently required.[100]

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96 Resolution 348/19/CONS

97 European Electronic Communications Code, EC, 11 November 2018, Article 81, see https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972&from=EN

98 Line powering obligations were once a barrier to switch-off in some countries, but this issue has now been addressed in all reviewed countries with the UK being latest in 2018. Ofcom decoupled in 2018 universal service and emergency issues from the copper network by changing the obligation for powered lines to battery back-up on demand. The UK WLR obligation will be in place for another 2 years, but Ofcom has signalled that this could change in the next market review.

99 https://www.openreach.co.uk/orpg/home/products/wlrwithdrawal/wlrwithdrawal/downloads/March_2019_Newsletter_Issue_1.pdf

100 FTTC/VDSL VULA is sold as an add-on service to LLU or WLR in the UK, implying that access seekers must purchase an analogue or copper line in order to provide broadband services. This may also explain the limited progress in the UK towards VoIP migration from PSTN.

4 Conclusions and recommendations

Our analysis shows that progress towards fibre deployment and copper switch-off in Europe is uneven. While certain countries, including Estonia and Sweden, have made significant progress towards switch-off, the pace of migration has been much slower in other countries such as Spain, Portugal and France – even in areas where fibre is widespread. Furthermore, countries such as Germany and the UK are unlikely to be in a position to migrate to fibre in the years to come, because fibre deployment has been limited, and attention has only recently shifted towards the investments required.

In areas where FTTH has been widely deployed or where other technologies such as FWA are more efficient, considerable benefits could be gained by facilitating switch-off. These include reduced operational costs and an improved business case for operators investing in fibre, improved quality of service for customers and wider benefits to the environment and society, including reduced CO2 emissions in relation to the data consumed.

Interviews, conducted with NRAs and stakeholders, suggest that there are a variety of factors holding back the migration to fibre, and that different countries have experienced different challenges. The reluctance of incumbents to invest in or access fibre networks has been a key constraint in some cases, while challenges in persuading customers and access seekers to migrate has hampered progress in others. Regulatory factors including long notice periods and associated wholesaling requirements for the closure of copper exchanges may have further contributed to delays and complexity in some countries which are otherwise ready to make the transition.

Based on our analysis of the key problems, underlying causes and good practice examples, we have identified the following areas where policy makers could take action to expedite the migration process:

Table 8 Main categories of challenges for migration to fibre and their potential policy solutions

Challenge	Causes	Potential solutions
Incumbents lack incentive to invest in FTTH	Absence of infrastructure competition Regulatory approach does not adequately reward FTTH investment	Consider SMP and/or BB CRD duct and pole access regulation Consider light touch FTTH access regulation in the initial phase Signal that copper/FTTC wholesale access prices would be permitted to increase once (and where) FTTH is widely deployed and can be supplied on a competitive basis
Incumbents refuse to engage in co-investment/access on other FTTH existing or prospective networks in cases where infrastructure duplication not viable	Historic reliance on own infrastructure Potential to deter alternative investments through threat of parallel operation/overbuild	Signal that incumbent engagement in co-investment or wholebuy schemes (e.g. where there is an alternative wholesale only investor) will be taken into account in the market analysis process, and that conduct meeting certain requirements would warrant forbearance on VHC regulation Where voluntary measures are insufficient, consider use of symmetric regulation to ensure engagement by all players in co-investment (relevant especially where multiple players, in advance of deployment)
Altnets lack incentive to migrate to fibre access or (co)invest in fibre	High barriers to deploying FTTH networks Copper rental relatively more profitable than fibre rental or own build	Consider SMP and/or BB CRD duct and pole access regulation, coupled with forbearance on or light touch FTTH access regulation and measures which encourage investment in or buy-in by altnets to existing fibre networks e.g. permitting volume and long-term discounts Signal that copper/FTTC wholesale access prices would be permitted to increase once (and where) FTTH is widely deployed and can be supplied on a competitive basis Establish/improve processes to enable switching between platforms

Challenge	Causes	Potential solutions
Customers resistant to switching	ADSL/FTTC is significantly cheaper than FTTH Customers cannot tell difference between FTTC/cable and FTTH products Practical challenges in switching platform Legacy equipment not supported on FTTH	Provide incentives for altnets to engage in fibre (co)investment, allow copper/FTTC wholesale prices to rise once (and where) FTTH is widely deployed Provide guidelines concerning advertising standards Establish/improve processes to enable switching between platforms For consumers: provide “plug and play” solutions, which support legacy equipment, and avoid the need for engineer intervention For businesses: provide bespoke support to facilitate migration of legacy equipment onto modern IP and/or mobile solutions
Regulation impeding or delaying migration	Long notice periods and/or onerous wholesaling requirements linked to copper switch-off Regulations require SMP or USO providers to make available analogue services Regulations require line powering for telephone lines	Review notice periods for copper switch-off noting that periods of 18 months or less have been achieved in Australia, Sweden (commercial agreement), Estonia and the US. Consider whether existing regulated and commercial fibre access and (co)investment opportunities are sufficient to support competition post copper switch-off Permit SMP operators to set phase out date for analogue wholesale and retail services Remove or replace regulations concerning line powering with an option for battery back-up

Source: WIK Consult

These actions can be categorised as follows:

- **Promoting infrastructure competition** to incentivise fibre deployment by the incumbent and alternative investors. Relevant actions include ensuring that duct and pole access are made effectively available and considering (initial) forbearance on or a light touch approach to fibre access regulation;[101]
- **Sending appropriate pricing signals** to encourage customers and alternative operators to migrate from copper to fibre. Specifically, the price of copper and FTTC could be permitted to increase once fibre is widely available and can be supplied on a competitive basis, and/or wedge pricing strategies are used;[102]
- **Encouraging operators (including the incumbent) to coalesce around the use of a single network** in circumstances where duplication of FTTH networks is not viable. This could involve the incumbent acting as an access seeker where there is an existing fibre network focused on wholesaling, or otherwise co-investing with other operators to deploy a single network in these areas. Symmetric regulation requiring all operators to participate in a co-investment scheme could also be considered in specific circumstances e.g. where there are multiple regional access providers and fibre deployment is not yet widespread;[103]
- **Facilitating exchange closure.** Authorities could review in light of experiences in Estonia, Sweden and Australia, whether notice periods for copper exchange closure could be reduced e.g. to 18 months in areas of widespread fibre availability, and whether existing regulation or commercial opportunities are sufficient to support competition on fibre access;
- **Informing customers of the benefits of fibre and supporting the switching process.** Relevant authorities could ensure that customers are made aware of the difference between copper, TV-cable and fibre offers, by setting appropriate advertising standards. Switching processes between platforms could also be improved to enable customers to move to alternative operators deploying fibre; and
- **Easing the process of phasing out legacy equipment.** Operators switching their customer-base to fibre can support the migration through “plug and play” devices and processes that support analogue equipment and avoid site visits. Meanwhile, more complex business needs should be managed through direct contact.

There may be scope for member states and NRAs to update and clarify regulations concerning copper switch-off in the context of the transposition and application of

101 See for example WIK (2016) for the EC, Regulatory, in particular access, regimes for network investment in Europe, and WIK (2019) Prospective competition and deregulation https://www.ofcom.org.uk/__data/assets/pdf_file/0020/145046/b-group-wik-report-annex.pdf

102 See discussion and reference literature in section 3.2.2.

103 For further discussion, see WIK (2020) for the UK BSG: Moving to a fibre-enabled UK: international experiences on barriers to gigabit adoption http://www.broadbanduk.org/category/bsg-reports/

provisions on “migration from legacy infrastructure” in the EU electronic communications Code.[104] There may also be a case to address these issues at EU level in any update made to Commission Recommendations concerning migration and the approach to access regulation and pricing of copper and VHC wholesale products.[105]

104 Article 81 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L1972&from=EN

105 Access regulation of NGA networks and migration are currently addressed in the 2010 Recommendation on NGA, while the relative pricing of copper and NGA is addressed in the 2013 Recommendation concerning cost methodologies and non-discrimination.