FTTH: a catalyst

for sustainable action

by Iskratel

Reducing carbon footprint of broadband access.

Key Findings

- HFC causes the highest CO_2 emissions, and they increase with data rates.
- Carbon footprint of VDSL is 20% lower than HFC.
- GE P2P is no better than VDSL in terms of carbon footprint.
- 10GE P2P ranks worst fibre technology; it is closer to HFC than to other fibre technologies.
- GPON is 4-20 times better than GE P2P and 10GE P2P even without over-subscription.
- XGS-PON causes up to 10% more emissions than GPON.

In light of the ambitious national sustainability goals set by the EU and member state governments, telecom operators and regulators cannot afford to ignore the environmental impact of their operations. Though they may be aware of carbon intensity of copper-based broadband access to a certain extent, they may not fully understand the overall environmental impact if their business models and technologies remain unchanged. Even when shifting their strategies from copper to fibre access, operators may still lack the relevant information on the impacts that their choices from the fibre menu have. While they may be inclined to pay attention on addressing profitability, the environmental impact of their operations must be weighed up carefully before fully deploying FTTH technology.

- In December 2020, the European Union updated its target to reduce emissions by at least 55 percent by 2030 [1] from 1990 levels. This aligns with ambitious national climate targets of Germany – a focus of this Executive Whitepaper – aiming to become greenhouse gas neutral by 2045. [2]
- These targets outline the goal to achieve a cut of at least 65 percent by 2030, compared to 1990 levels, and 88 percent by 2040. In Germany's Climate Action Plan 2050 [3], sectoral targets were drawn up for various industry sectors. This aligns with the German Federal Climate Change Act and its objectives to limit the increase in the global average temperature to below 2°C and preferably to 1.5°C above pre-industrial levels. [4]

With energy consumption having a direct impact on the environment, operators should be turning to initiatives and technology choices that significantly reduce the amount of carbon emissions emitted into the atmosphere and reduce companies' overall carbon footprints. The greenest kWh is the one that is not consumed or generated.

Telecom operators that delay taking sustainable actions risk threatening their own business success in the long-term. Operators are becoming increasingly aware of the importance of acting responsibly in full view of customers who have become more accustomed to utilising sustainable products. [5] Public image can be enhanced with the visibility of their efforts to meet the environmental sustainability goals. This Executive Whitepaper will aim to shed light on the immense impact that the shift from copper to Fibre-To-The-Home (FTTH) will have on the ability to meet the European or national environmental-sustainability goals. It will provide a deeper insight into the environmental impact of fibre-access technologies and into the adverse effects wrong FTTH choices can have on the environment. In addition, it will draw attention to often overlooked caveats of fibre-access trends and technologies, and the notable effect that even small differences can have.

How much is 8,000 tonnes of CO2?

- A car that consumes seven litres of petrol per 100km and travels 15,000km per year, releases 2.44 tonnes of CO_2 into the atmosphere per year. [8] It takes 3,300 cars to release 8,000 tonnes of CO_2 – which means a million HFC users equates to putting 3,300 additional cars on the roads unnecessarily.
- A hectare of woodland neutralises 10 tonnes of CO_2 a year. [9] Connecting a million HFC users in Germany requires 820 hectares of woodland. In other words, a million HFC users can effectively destroy four Tiergarten Parks every year.
- Phytoplankton in the world's oceans contributes around half of CO_2 absorption on the planet. Large whales feed in deep ocean, while their iron-rich faeces feed phytoplankton near the surface. By feeding the phytoplankton, a single large whale contributes to absorption of around 25 tonnes of CO_2 per year. [10] Therefore, 330 whales from the world's oceans are required to offset the 8,000 tonnes of CO_2.

Comparison between Copper and Fibre-Based Technologies

If we look at broadband access technologies from the perspective of power consumption, we see that the subsequent emissions of CO_2 are a result of a mix of fossil fuels and renewable energy sources to generate electricity. To make a relevant comparison between copper-based and fibre-based access technologies, we focus on commercial packages with data rates of 50 megabyte per second (Mb/s) per user, that are attainable over copper and fibre alike. This is only in relation to power consumption at the Central Office and remote locations, since the consumption of Customer-Premises Equipment (CPE) does not vary much when specific access technology is chosen.

The analysis shows that Hybrid fibre-coaxial (HFC) with DOCSIS 3.0 consumes around 2.3Watt (W) per individual user if fully utilised. [6] With oversubscription it may be lowered to 0.23W per user. This leads to power consumption of 21 kilowatt-hour (kWh) per user per year.

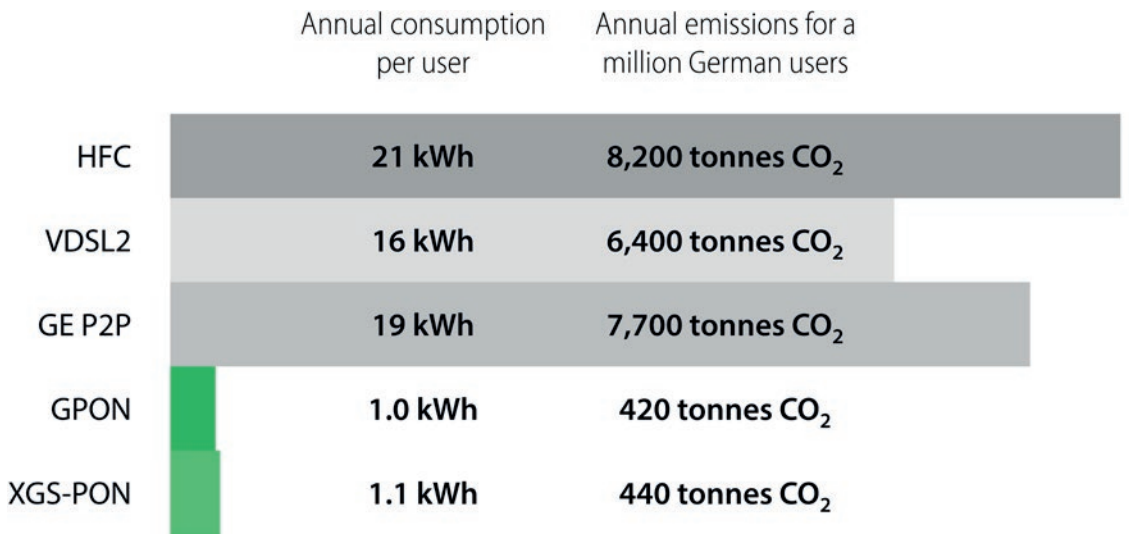
Focusing on Germany as an example, and taking the specific CO_2 emission factor of Germany's electricity mix – which was

In Focus: Access Technology in Germany

The majority of existing broadband connections in Germany still rely on copper. In 2020, there were 8.7 million HFC users, 16.8 million VDSL users (out of a total 25.6 million xDSL users), and 1.87 million active FTTH users. [18] If we extrapolate figures for HFC and VDSL power consumption, we estimate that the access equipment for 25.5 million HFC and VDSL users generated around 95,000 tonnes [19] of CO_2 in 2020 alone. On the other hand, if these 25.5 million users had been using GPON instead, they would have generated around 5,000 tonnes [20] of CO_2 in 2020.

This is a difference of around 90,000 tonnes of CO_2 which were released into the atmosphere in 2020 by using copper-based access instead of fibre. It required around 9,000 hectares of woodland to absorb it. Or, it had the same effect as putting an additional 37,000 petrol-fuelled cars on German streets, or removing 3,600 whales from the world's oceans.

It should be noted that these figures only provide the impact of the access-technology dependent part of the access network; they do not include other parts of operators' networks or the CPE. The figures may be rough estimates based on several simplifications; however, they clearly highlight the magnitude of the environmental damage done to the planet – in a single year, in Germany alone.



401 grams of CO_2 per kWh in 2019 [7] – this yields more than 8kg of CO_2 per user per year. A million HFC users therefore generate 8,000 metric tonnes of CO_2 per year.

The calculations are made by taking 401 grams of CO_2 per kWh as the carbon cost of electricity generation in Germany. The projections estimate a decrease to 366 grams in 2020, while the emissions from electricity generation should fall by some 20% by 2030 compared to 2020 levels. [11] Even if the figures are reduced by, say 30%, the equivalent emissions from deploying HFC are still incredibly high.

Let's also have a look at VDSL with vectoring. With an average consumption of 1.8W per user [12] (which can be several times higher in rural areas, as shown in analysis of rural deployments in Germany [13]), it requires 16kWh per user per year, or the emissions of 6,400 tonnes of CO_2 per year, for a million users. This may be 20% less than HFC, but it still amounts to 640 hectares of woodland – three Tiergarten Parks – 260 whales.

Surprisingly, Point-to-Point (P2P) FTTH performs no better than VDSL. The average consumption is 2.2W per user [14] (even more than VDSL) and may be as high as 2.5W per user [15] in rural areas in Germany. Subsequently, P2P FTTH generates around 7,700 tonnes of CO_2 for million users per annum. On the other hand, GPON FTTH performs incomparably better. When fully utilised, it requires only 0.12W per user [16], or 1.0kWh per user per year. The carbon footprint of a million GPON users is 420 tonnes of CO_2 per year. For a fair comparison, this still represents 42 hectares of woodland – but it is 20 times less than HFC, VDSL2 or P2P FTTH. The consumption figures for GPON are a further 10 times lower with a typical GPON oversubscription. In the case of XGS-PON FTTH, the consumption per user is 0.13W, or 1.1kWh per user per year, with the footprint of one million users being 440 tonnes of CO_2 per year. [17] All in all, comparable to GPON.

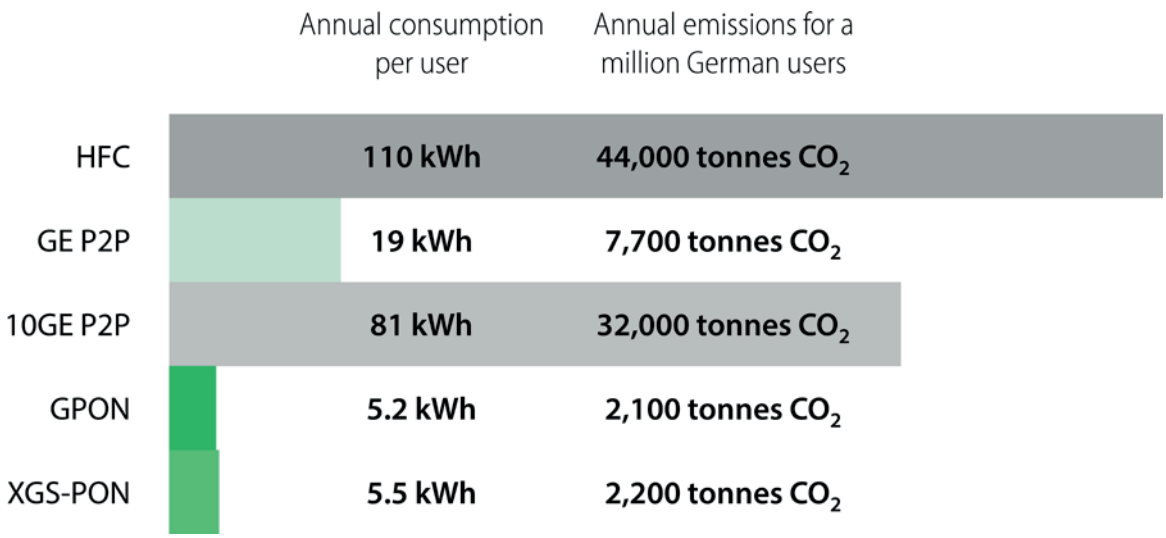
Choosing Correctly from The Menu of FTTH Technologies

To make a fair comparison of P2P, GPON and XGS-PON flavours of FTTH, we focus on data rates more typical for FTTH – the commercial package in this case is 250Mb/s per user. We only study the consumption at the Central Office.

First of all, an important observation: HFC should not be considered for such data rates – at least not from the perspective of power consumption and related carbon footprint. With only a handful of users per service group, HFC consumes a staggering 13W per user if fully utilised, reducible to 1.3W per user with heavy oversubscription. This requires 110kWh per user per year, or the emissions of 44,000 tonnes of CO_2 per year for a million HFC users. At 250Mb/s per user, VDSL cannot be used.

How does it all compare to proper choice of FTTH?

- Choosing GE P2P instead of GPON generates an additional 7,500 tonnes of CO_2 emissions every year per a million users in Germany. This amounts to 3,000 more cars, wiping out four Tiergarten Parks, or removing 300 whales from the oceans.
- Choosing 10GE P2P instead of XGS-PON generates an additional 32,000 tonnes of CO_2 emissions every year per a million users in Germany. This equals 13,000 more cars, wiping out 15 Tiergarten Parks, or removing 1,300 whales from the oceans.



Let us compare FTTH in more detail. For gigabit P2P FTTH, the average consumption is 2.2W per user which requires 19kWh per user per year. Subsequently, GE P2P FTTH generates around 7,700 tonnes of CO_2 for one million users per annum. Surprisingly enough, 10-gigabit P2P FTTH performs four times worse than GE P2P. With 9.2W per user and 81kWh per user per year, 10GE P2P FTTH generates more than 32,000 tonnes of CO_2 for a million users per annum [21]. In Germany, this is equal to putting 13,000 petrol-fuelled cars on the streets, cutting down 3,200 hectares of woodland (15 Tiergarten Parks) each year, or removing 1,300 whales from the planet's oceans.

In contrast, PON technologies consume significantly less electricity than P2P FTTH. Specifically, fully utilised GPON FTTH requires only 0.59W per user, or 5.2kWh per user per year. The footprint of a million GPON users is 2,100 tonnes of CO_2 per year, which still amounts to one Tiergarten Park or 84 whales removed from the oceans, but it is still 4 to 15 times less than GE and 10GE P2P respectively.

In Focus: What It Will Mean for Germany

In 2020, there were 1.87 million active FTTH users in Germany. Predictions estimate that there will be a rapid growth of FTTH, reaching 25 million active FTTH connections in 2026.[22] In other words, there will be 23 million new FTTH users in the next five years. Clearly, their environmental impact will vary considerably depending on the choice of fibre-access technology. Therefore, selecting PON technologies over P2P is the only acceptable choice if operators wish to make a positive contribution to reducing the carbon footprint of their operations.

Assuming the average commercial package is 250Mb/s, and taking carbon intensity per kilowatt-hour (CIPK) 2019 level into consideration, if this is lowered by 30% to 0.280kg/kWh, the emissions for these new 23 million users will be around 3,500 tonnes of CO_2 in 2026 if they are connected with GPON or XGS-PON. This is equivalent to:

- Destroying 350 hectares of woodland each year
- Putting an additional 1,400 cars on Germany's streets
- Removing 140 whales from the world's oceans each year

Equally, the emissions in 2026 will be:

- An estimated 120,000 tonnes of CO_2 higher if connected with GE P2P
- An estimated 520,000 tonnes of CO_2 higher if connected with 10GE P2P

The conclusion is painfully simple. Connecting 23 million additional FTTH users with GE P2P technology will have the same effect as:

- Destroying 12,000 hectares of woodland each year (or 52,000 hectares for 10GE P2P)
- Putting an additional 50,000 cars on Germany's streets (or 210,000 for 10GE P2P)
- Removing 5,000 whales from the world's oceans each year (or 20,000 for 10GE P2P)

Clearly, the wrong technology choices can have serious repercussions on the environment.

XGS-PON FTTH follows GPON FTTH closely, with figures 6% higher than GPON FTTH. All figures for PON are all calculated without oversubscription. With an oversubscription of 10, the figures for GPON and XGS-PON are a further 10 times lower. Beyond any doubt, PON FTTH is superior to P2P FTTH if energy efficiency and carbon footprint are compared.

Where do we go from here?

While European countries may be aware of the carbon intensity of copper-based broadband access, operators and regulators' business models and technologies must be carefully considered. In particular, the levels of power consumption and CO_2 emissions directly impacting the environment.

When migrating their business strategies from copper- to fibre-based access technologies, operators have an obligation to make sure they have considered the environmental impact of their operations.

Therefore, the industry must not only focus on adopting the most cost-effective and efficient technologies, but also those that are the most environmentally friendly.

Literature and notes

https://ec.europa.eu/clima/eu-action/international-action-climate-change/climate-negotiations/paris-agreement_en

2 https://www.cleanenergywire.org/factsheets/germanys-climate-action-law-begins-take-shape

3 https://www.bmu.de/en/topics/climate-adaptation/climate-protection/national-climate-policy/climate-action-plan-2050-germanys-long-term-low-greenhouse-gas-emission-development-strategy

4 https://www.whitecase.com/publications/alert/reshaping-climate-change-law

5 https://www.iskratel.com/en/resources/white-papers-and-articles/telecom-environmental-sustainability

6 For HFC, only consumption of fibre nodes and amplifiers used, with 60W per node on average, increased by 25% for air conditioning. The consumption of CMTS and aggregation layer not included.

7 https://www.umweltbundesamt.de/en/press/pressinformation/co2-emissions-per-kilowatt-hour-of-electricity-in

8 https://ecoscore.be/en/info/ecoscore/co2; https://www.unitjuggler.com

9 https://www.delijn.be/en/overdelijn/organisatie/zorgzaam-ondernemen/duurzaamheid/co2-uitstoot-voertuigen.html

10 https://royalsocietypublishing.org/doi/10.1098/rspb.2010.0863?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub

11 https://www.umweltbundesamt.de

12 For VDSL, only consumption of DSLAMs used, with 750W per 512-port DSLAM, increased by 25% for air conditioning at the central office and/or remote locations. The consumption of BRAS and aggregation layer not included.

13 Prysmian Group, Energy consumption of telecommunication access networks, October 2020, https://www.prysmiangroup.com/staticres/energy-consumption-whitepaper/index.html

14 For GE P2P FTTH, only consumption of OLTs used, with 42W per 24-port OLT, increased by 25% for air conditioning at the central office. The consumption of BNG and aggregation layer not included.

15 Prysmian Group, Energy consumption of telecommunication access networks, October 2020, https://www.prysmiangroup.com/staticres/energy-consumption-whitepaper/index.html

16 For GPON FTTH, only consumption of OLTs used, with 76W per 16-port OLT, increased by 25% for air conditioning at the central office. The consumption of BNG and aggregation layer not included.

17 For XGS-PON FTTH, only consumption of OLTs used, with either 164W per 8-port OLT, or 484W per 24-port OLT, increased by 25% for air conditioning at the central office. The consumption of BNG and aggregation layer not included.

18 DIALOG CONSULT/VATM, 22. TK-Marktanalyse Deutschland 2020, October 2020, https://www.vatm.de/wp-content/uploads/2020/10/VATM_TK-Marktstudie-2020_061020_a.pdf

19 The estimated figures span between 63 and 128 thousand tonnes of CO_2 annually, depending on the HFC oversubscription level.

20 The estimated figures span between 1 and 10 thousand tonnes of CO_2 annually, depending on the GPON oversubscription level.

21 For 10GE P2P FTTH, only consumption of OLTs used, with 354W per 48-port 10GE P2P OLT, increased by 25% for air conditioning at the central office. The consumption of BNG and aggregation layer not included.

22 Compiled from studies by iDATE/FTTH Council, VATM and Breko.

For more information, see www.iskratel.com