A joined-up approach to operators' technology choices could deliver green benefits

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Operators are increasingly keen to showcase their green credentials in terms of both the direct impact of their operations and the indirect benefits of digitalisation. In this article, we quantify the direct environmental impact of various access technologies.

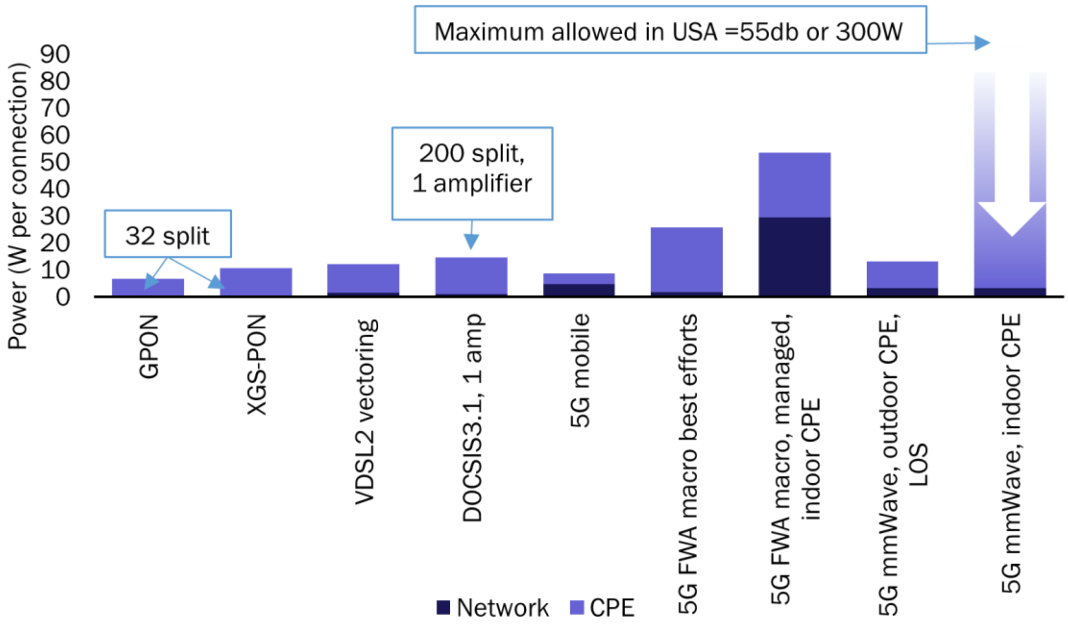
The energy intensity of different access technologies varies significantly

Most of the carbon footprint (measured in carbon dioxide equivalents (CO_2e)) of network operations comes from emissions from power supply. As such, one must measure the energy consumption to understand the global warming potential. This should be measured on a per-connection basis, rather than a per-gigabyte basis, otherwise an operator that does nothing can become miraculously more efficient or greener while consuming ever more power as traffic levels rise.[1] Figure 1 shows the typical power used per line for a range of access technologies.[2]

1 The British economist William Jevons pointed out back in 1865 that efficiency encourages demand; this is a paradox that hampers carbon reduction when it is so tightly bound to a cost element.

2 Analysis adapted and harmonised from multiple sources, principally: Huawei, *5G Power: Creating a green grid that slashes costs, emissions & energy use*; Prysmian Group (2021), *Energy consumption of telecommunications access networks*; Sivers Semiconductors and academic papers including Butt, R., Idrus, S., Zul, N. and Ashraf, M. (2018), 'A Survey of Energy Conservation Schemes for Present and Next Generation Passive Optical Networks', *Journal of Communications*, 13 (3) and Aleksic, S. and Lovric, A. (2011), 'Energy Consumption and Environmental Implications of Wired Access Networks', *American J. of Engineering and Applied Sciences* 4 (4): 531–539. While there is considerable variation in assumptions and outputs, they point to broadly the same conclusions around the relative efficiency of wireline technologies.

Figure 1: Power used per connection, by broadband access technologies



Source: Analysys Mason, 2021

There are two key elements to the energy costs shown in Figure 1:

- **CPE**, which includes ONTs, FWA transceivers, modems and handsets, but not indoor network elements
- **powered network equipment** at the central office (CO) or cell site, plus anywhere between these and the end users. This is typically a fixed cost divided by the number of premises passed. For comparison purposes, our calculations all imply full utilisation.[3]

xPON technologies have a lower power consumption than other wireline solutions because there is no powered plant between the CO and the end user.

The energy costs for fixed-wireless access (FWA) on an all-purpose 5G macrocell hinge on what is counted as an 'already-incurred' cost. Some argue that FWA network capex is minimal because mobile network coverage is a sunk cost and therefore all FWA costs come from CPE. By the same reasoning, the network-related energy costs associated with FWA are nil (or minimal) because they too count as already-incurred. However, some MNOs plan to use much more 5G capacity for FWA than for mobile,[4] and treating power as an already-incurred cost in these circumstances may be disingenuous. In any case, FWA can involve higher transmission power than mobile, in which case there is a marginal cost.

The number of premises passed is easily determined for wireline technologies. However, it is less clear for FWA because the number of premises that one network can address depends on the committed information rate (CIR) per subscriber. A typical macrocell might cover about 1500 households, though this number is typically lower in areas where FWA is the most economically attractive. A 5G macrocell base station requires about 4.7kW on top of the power required for previous generations. As a consequence, optimising transmission power efficiency,

3 We have not considered transport, core and data centres because these would have similar energy costs in each case.

4 For more information, see Analysys Mason's Verizon's post-auction plans for FWA will run up against the limitations of 5G.

especially by enabling powering down, is a topic of interest in 5G circles. For a best-efforts 5G FWA service, 4.7kW divided by the number of premises passed gives a low figure if the energy cost is shared (somewhat arbitrarily) 50:50 with mobile. However, if all of these households subscribed to FWA, the service would be intolerably poor.

For services defined by a CIR that is typical for B2C broadband, the network-related energy consumption per connection is much higher. Figure 1 shows an example of a 150Mbit/s FWA service with a CIR of 15Mbit/s (an overbooking ratio of 10:1) that serves 80 households on a 5G macrocell, where the remaining capacity is allocated to mobile. Indoor CPE-related energy costs are a little higher for FWA than is typical for wireline technologies, but is at a level easily absorbed by households.

Our calculations for 5G mmWave are based on small cells serving 100 premises. These require much less power (300W) than macrocells. The most important variable determining the aggregate power consumption with mmWave FWA is whether the CPE is indoors or outdoors. Operators prefer self-installable indoor CPE. A reasonable assumption (depending on construction materials of the building) is that an additional 15dB is required for indoor CPE compared to outdoor CPE, assuming the same antenna gain and the same cell radius.[5] This could be costly in terms of CPE power (if the same performance is maintained), but recent improvements in antenna gain in indoor mmWave FWA CPE mean that there can be an acceptable trade-off between power, performance and equipment costs, at least in certain kinds of buildings.

Operators, vendors and governments currently have incentives not to reap the benefits of efficiency

Maximising the use of fibre networks could significantly reduce carbon emissions. FTTP not only has the best performance, but short-range wireless with fibre backhaul is more energy-efficient than macrocell-based wireless. This is the basis of a green case for actively steering wireless traffic from macrocell networks to indoor wireless networks (principally, though not exclusively, Wi-Fi).

Another way of putting this is that use of mobile networks should be minimised where fixed (and therefore FTTP) and mobile networks are substitutable.[6] A typical integrated fixed+mobile operator uses an order of magnitude more power on the RAN than on fixed access, and carries an order of magnitude more traffic on the fixed network than on mobile.[7] However, the commercial importance of high-yield mobile data to operators and of RAN equipment to multi-access vendors, plus the taxation benefits of spectrum licensing to governments, all mean that no individual stakeholder is incentivised to reap the benefits of power efficiency. Arguably, they are incentivised to ignore these benefits.

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5 Sivers Semiconductors (2018), *mmWave for 5G – FWA a review.* Available at: https://www.sivers-semiconductors.com/blog/mmwave-for-5g-fwa-a-review/.

6 There are many cases where 5G mobile could bring real indirect benefits. See for example, Analysys Mason's Green 5G: building a sustainable world.

7 Lorincz, J., Capone, A., and Wu, J. (2019), 'Greener, Energy-Efficient and Sustainable Networks: State-Of-The-Art and New Trends', *Sensors*,19 (22).

The full emissions picture depends on more than just the choice of technology

More-efficient overlay networks (5G and FTTP) will increase the overall power consumption used for telecoms networks until legacy networks are switched off. Switching these off makes more difference than the efficiencies of the newer technologies.

Whether power efficiency translates into CO_2e reduction depends largely on energy supply. The composition of energy sources on the grid is outside operators' control, although contracting with suppliers that use 100% renewable energy sources does encourage investment in renewable energy generation. (It does not, however, mean no emissions.)

The figures above apply only to the operation of networks, and not their construction. 5G macrocell deployment usually incurs construction work on towers (this accounts for a surprisingly high share of 5G roll-out capex), and 5G mmWave will incur substantial amounts of groundwork. However, FTTP will incur more construction work, and from a green perspective this is FTTP's Achilles Heel. Indeed, it may take several years for the carbon savings of FTTP to offset the carbon and/or energy costs of digging up streets with JCBs and jackhammers.