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Dispelling the Myth of Sustainability in 5G Mobile Networks: What's Worth The Investment?

Overview. We wrote this Insight Note for two reasons: 1. The rise in cost of energy threatens to stress the financial performance of service providers; and 2. We want to provide context for potential investments in power saving technologies to help investors decide which would be worthwhile. This is also a good time to note that power consumption has become a confounding issue because of misleading statements by different industry lobbying groups. Thus, we aim to explain in factual terms the depth of the power challenge that 5G raises and provide a guideline as to which areas one needs to consider investing in.

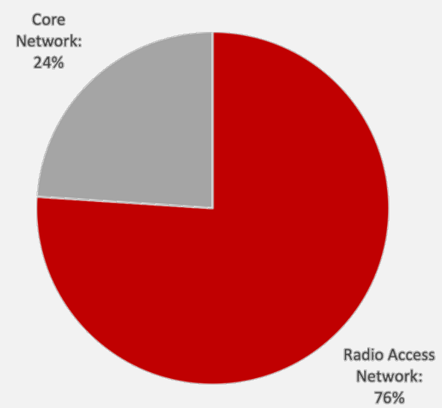
The Sustainability Challenge. Three critical factors have contributed to shaping the discussion around power consumption in telecom networks, and specifically 5G wireless networks:

1. The rise of Environmental, Social, and Governance (ESG) investing; the environmental aspect is specific to our topic.
2. The inflationary pressure in energy prices following the opening of economies post the Covid-19 pandemic.
3. Geo-political factors including the Ukraine war and US-China tensions which saw unprecedented sanctions against Chinese telecom (Huawei and ZTE) and semiconductor companies.

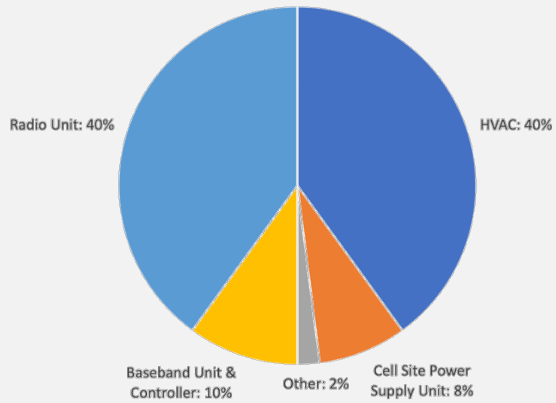
These factors came to the fore at the time mobile operators began deploying 5G technology starting in 2019. 5G practically doubles the power requirements for existing cell sites. With this backdrop, mobile network operators were silent on the issue of 5G power consumption. A quick review of

Where The Energy is Spent

The radio access network (RAN) accounts for most of the energy draw in mobile networks accounting for around 76% of the total (excludes energy consumed in offices, retail stores, fleets, etc.). Of this 76%, the radio unit of the base station accounts for about 40% of energy draw while the cell site HVAC system accounts for another 40%. Reducing HVAC requirements and improving the power efficiency of base station radios lead to significant gains in energy savings.



Allocation of Power Consumption in Mobile Network.*



Allocation of Power Consumption in the RAN.*

* Based on Vodafone reported data.

their ESG reports quickly leads one to note that much of the information they publish serves to meet the minimum regulatory requirements without providing meaningful information to assess the impact of energy on their operations. Juxtaposed to this silence, industry lobbyists were hard at work churning whitepapers and information that often have little validity. We had many discussions with industry professionals who were bewildered by the confounding information disseminated by industry players.

Dispelling the Myths Around Energy Consumption. There are three facts to note about energy consumption in mobile networks.

Fact 1: 5G consumes more power than 4G in absolute terms. This is simply because energy consumption is directly proportional to the carrier bandwidth. Additional factors that determine the power budget include the number of transmit antennas, the frequency band, and implementation options. 5G uses wider channel bandwidth – typically 100 MHz in mid-band spectrum whereas 4G/LTE is based on 20 MHz channel. Given a certain power spectral density limit (Watt/MHz), 5G uses more power (W) by the nature of its higher utilization of spectrum.

5G has a higher spectral efficiency than 4G/LTE (bps/Hz). This is the reason for the claim that 5G is more efficient than LTE as expressed in terms of Watt/Mbyte. However, the amount of spectral efficiency gain of 5G over 4G only becomes meaningful in mid-band spectrum (e.g. 2.5 GHz and 3.5 GHz) where 4G has an inefficient MIMO as well as control and signalling implementation. In low band spectrum (sub 2 GHz), the spectral efficiency gain of 5G is only about 5-10% compared with 40%-50% in mid-band spectrum.

Fact 2: Energy is a small part of operational expenditures. Mobile networks have increased in complexity over time as they grew larger to support multiple radio access technologies and frequency bands. Obviously, the larger these networks are, the greater demand for energy. Yet, the percentage of opex spent on energy is relatively small, especially in North America where the price of electricity is stable and low in comparison with that in Europe and Asia.

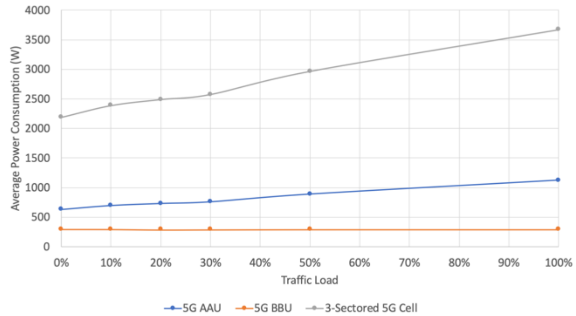
Energy expense as % of Opex[1] (2021)	
AT&T	1.1%
Vodafone[2]	2.12%
China Mobile	5.0%

As a consequence, we see Asian operators who led the deployment of 5G networks are also leaders in testing techniques to reduce power consumption. For some, such as in China, this includes a complete shut-down of the 5G network at night when traffic demand is low!

Fact 3: Using ratios such as unit of energy per unit of traffic (e.g. Watt-hour/Mbyte) is not meaningful and could even be misleading. First, the notion that energy consumption is a function of traffic is not wholly accurate. In a 5G wireless base station, the radio power consumption shows a dependency on traffic, but it is not zero when there's no traffic. The power consumption for baseband units is relatively independent of the traffic load. Second, quoting performance in terms of Wh/MB (or similar ratios) hides the absolute amount of energy consumption, which is what really matters. This renders such ratios interesting for gauging the efficiency of successive generations of a certain technology, but not meaningful for gauging expenditures or impact on environment.

[1] Opex includes COGS, SG&A, depreciation and amortization and other expenses.

[2] Based on Vodafone reported results for fiscal year ending March 31, 2022.



Average power consumption in a 3-sector 5G base station as measured by a Chinese operator for a ZTE base station.

The Capex vs. Opex of Energy. When service providers roll out a new technology, they need to increase the power available at the cell site in order to accommodate the additional spectrum bands and equipment related to the upgrade (e.g. radios, baseband, backhaul, HVAC, batteries and power backup systems, cables, etc.). This is a capex impact. On the other hand, the cost of energy ($/kWh) is the opex portion.

5G presents a capex challenge because 5G almost doubles the power requirements at the cell site (depending on the amount of spectrum and operating systems). This has many operators think twice about their capacity requirements and select the appropriate equipment that best meet their cost and performance trade-offs. For instance, operators opted to deploy 32T32R radios instead of 64T64R to exchange higher capacity for lower energy requirements. In short, the capex challenge is felt more uniformly by service providers.

In contrast, the energy opex impact varies depending on several factors including foremost the cost of energy. Thus, the opex impact is regional and is felt to varying degrees by the different service providers.

Assessing Energy Efficiency Innovations. New solutions to improve the efficiency of wireless networks are available. They could be categorized under hardware and software solutions. These solutions include, for example, semiconductor devices and processor accelerators to improve the efficiency of radio and baseband units. They also include software techniques that partially or fully power down certain resources. Moreover, the advent of Open RAN led to the rise of several new companies developing RAN subsystems such as remote radio units and virtualized baseband units, in addition to companies developing software applications that make use of the newly standardized base station interfaces. While it is not our objective to expand on energy saving techniques here, we wanted to provide investors a framework to evaluate the potential impact of such technologies.

The simplified framework maps the energy impact onto the financial impact for the service provider to assess the level of traction a solution could achieve. It is important to note that this framework is one in a tool kit, so it needs to be considered as part of a process: it gives visibility into only one aspect among many that cannot as well be ignored.

		Financial Impact	
		Opex	Capex
Energy Impact	Peak		Hardware solutions
	Average	Software solutions	Hardware solutions

Solutions that address the peak-power demand in wireless networks have first priority. They help reduce both capital and operational expenditures, thus they have the most impact. Typically, such solutions are hardware solutions that include semiconductor technologies, lithographic process technology, amplifier linearization and compensation techniques and radio architecture and design. All service providers would be interested in such solutions since the benefits are immediate and relatively easy to quantify. However, the interest is highest during the network refresh cycle where there is a high certainty of the business case.

Software solutions, including the use of AI technology, come in second order of interest since they affect the average energy consumption and have an impact on opex, but limited if no impact on capex (since they largely don't impact peak power consumption). Such solutions are often traffic dependent and include some type of powering-down resources to save energy (sleep modes). Thus, they lead to loss in capacity. Service providers in high energy-cost areas, such as Asia and Europe, would value these technologies more readily because the threshold for a positive business case is lower. To illustrate, a 25% savings in the electricity bill reduces China Mobile's opex by 1.25%, whereas the same savings would only shave 0.28% off AT&T's opex. Therefore, operators paying high prices for energy are the most amenable to trade-off capacity for power savings.

The framework explains China's leadership in field testing and implementing software-based techniques to minimize the power consumption in 5G networks. As an interesting related note, the leading position Huawei and ZTE have in designing power-efficient radios would erode because of their inability to access the semiconductor devices necessary to remain at the leading edge of the power efficiency curve.

Key Takeaways and Implications

1. Power consumption accounts for a relatively small percentage of a service provider's operational budget with large geographic variance: order of 1% in North America up to 5% in China with Europe's energy cost rapidly spiraling upwards.
2. All service providers would be equally interested in reducing peak power requirements of new radio access technologies. This saves both capital and operational expenses. Peak power is typically related to hardware technologies especially in the radio unit which accounts for a large part of the base station power consumption.
3. Service providers in high-energy cost areas such as China, and now Europe, would be most interested in software-based solutions. These solutions impact the opex spent on energy and involve trading off capacity for lower power consumption.
4. The framework of peak/average energy vs. capex/opex financial impact serves the purpose of predicting the rate of adopting new technologies and by whom. However, we note that this framework is only one in a set of tools we use in evaluating such investments and market evolution.

About Xona Partners

Xona Partners (Xona) is a boutique advisory services firm specialized in technology, media and telecommunications. Xona was founded in 2012 by a team of seasoned technologists and startup founders, managing directors in global ventures, and investment advisors. Drawing on its founders' cross-functional expertise, Xona offers a unique multidisciplinary integrative technology and investment advisory service to private equity and venture funds, technology corporations, as well as regulators and public sector organizations. We help our clients in pre-investment due diligence, post investment lifecycle management, and strategic technology management to develop new sources of revenue.

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