Wasted Electrical Power Lost by Power Amplifiers (PA)

ABTRACT: Power Amplifiers are a necessary and critical part of every mobile phone communication, GPS device, drone controller, and satellite communication. The non-linear nature of the signals that the PAs amplify, constrain the PA to operate in an inefficient range for the vast majority of these communications. Often this inefficiency can be in the 10% range – causing the remaining 90% of the electricity to be converted to heat. [1]

The first step in reducing this wasted energy is to be able to quantify it. This task is vastly complicated by the number and variety of factors which significantly impact power consumption:

- the range of mobile phone generations 2G, 3G, 4G, LTE, 5G across base stations
- the dynamic nature of fielded phone generations – 2G and some 3G field base stations are being/have been replaced by 5 G installations
- some base stations use multiple generations of equipment simultaneously
- the definition of the size and scope of what constitutes a 'base station' is far from fixed. Most telecommunication operators refer to a base station as a collection of several transceivers operating at one or more frequencies; some operators count each frequency as a different base station; China considers almost every G5 equipment as its own base station – considerably inflating the number of Chinese base stations.

Calculating Global Telecommunications Electricity Costs – in Total

During the calendar year of 2020, GSMA Intelligence [2], a source mobile industry insights, forecasts, and research, conducted an extensive study of energy efficiency of mobile systems. Published in June 2021,[3] the study was based on an impressive data sample:

- 7 Telecommunications Operators (British Telecom, Deutsche Telekom, Etisalat, Globe, KPN, Smart, and Vodafone)
- 31 telecommunications networks across these operators
- Data sites spanning 28 different countries.

This study provided a figure for the average energy used by a base station site for a year. Specifically, "For the 31 networks covered, one mobile connection required an average of 14.8 kWh of energy during the 12-month period, while one network site used 28,665 kWh for the same period." The standard deviation on this value was high indicating that there is significant variability in these averages – which is to be expected for a large sample of of 31 networks spanning 28 countries of mobile phone usage.

Thus, we can calculate the average electricity used by a Base Station per Hour …

2020: 28,665 kWh divided by 365 days divided by 24 hours = 3.27 kWh average usage.

2023: 3.27 kWh average usage multiplied by 1.7 = 5.49 kWh

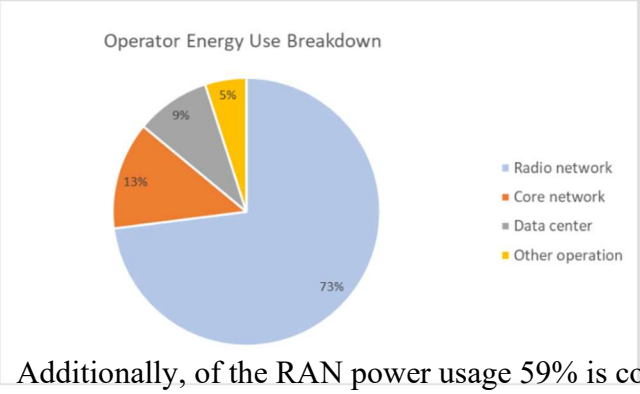
(In moving from 2020 to 2023, the 3.27kWh figure is increased by a factor of 1.7 [4] to reflect the increasing power as sites convert from 4G and below to 5G.)

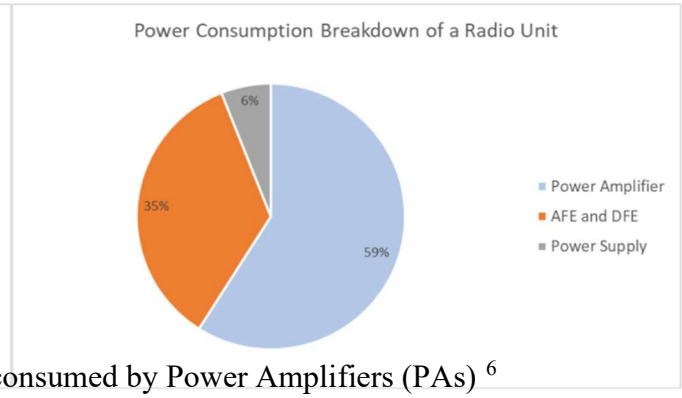
Year	Base Stations	kWh	Hours	Days	kWh	Annual Cost
2020	5,900,000	3.27	24	365	0.121	$ 20,449,808,280
2023	9,000,000	5.49	24	365	0.121	$ 52,372,623,600

Narrowing this network figure to Base Station and ultimately to Power Amplifier electricity usage…

Calculating Global Telecommunications Electricity Costs – Per Base Station

Organizations promoting the use of "green technologies" and saving energy have collected some good data on base station energy usage. It seems to be well established that 73% of the energy of the participating operators is consumed in the radio access network, RAN.[5]





Additionally, of the RAN power usage 59% is consumed by Power Amplifiers (PAs) [6]

RAN Power % * Power Amplifier Power % = % PA electricity use

73% 59% = 43% consumed by PAs

Calculating Global Telecommunications Wasted Electricity Costs

Nominally 90% of that power is wasted and converted to heat.[7] As a lower bound let us assume that only 80% of the power is wasted. This yields between…

90% of 43% = 38.7%

80% of 43% = 34.4%

Ranging between 18 to 20 billion dollars of wasted electricity converted to heat.

Data Sources

[1] https://www.docomo.ne.jp/english/binary/pdf/corporate/technology/rd/docomo6g/GreenMobileNetworksWhitePaper_22February2023.pdf
[2] https://www.gsmaintelligence.com/
[3] https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=60621137&file=300621-Going-Green-efficiency-mobile.pdf
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