CENIC Energy Innovations and Middle-Mile Networks

Today, the environmental impacts of broadband networks are not well understood. The infrastructure required to run these networks requires power, which in and of itself, releases carbon and other emissions into the atmosphere. Hence the power consumption of broadband networks matters. Further, with electrical power rates expected to rise significantly due to elevated wildfire risk and renewable energy costs, a balanced, clean, and stable power budget becomes even more critical.

Many promising power-thrifty innovations – including smart agriculture, just-in-time energy management, or remote work, education, and healthcare – depend on Internet-based middle-mile networks to function, so these networks themselves must run as efficiently as possible to avoid erasing any gains they enable.

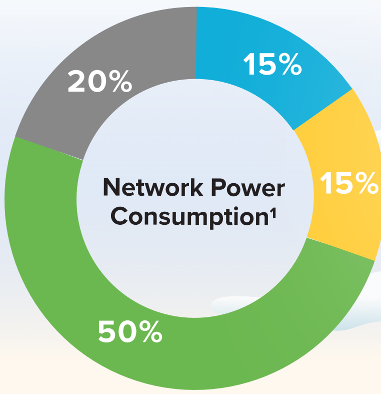
Network Power Consumption from Core to Edge

CORE EQUIPMENT

The manufacture, transportation, upgrade, and disposal of the physical materials that make up the network – including fiber, routers, switches, transponders, amplifiers, antennas, etc.

TRANSMISSION

The means by which data traffic is made to flow along the network from core to edge – the processing that must be carried out to perform this function, and the power needed to cool the equipment.



EDGE DEVICES

This includes customer premises equipment like consumers' computers, tablets, smartphones, modems, and WiFi routers, but in the "Internet of Things" can include smart home, industrial, and environmental devices like sensors/cameras, appliances, and thermostats.

DATA STORAGE

Datacenters and hyperscalers where data is stored and made available for almost instant access. Often described as "the cloud," these vast facilities can be power-hungry on a significant scale, and present major cooling challenges.

[1] New Perspectives on Internet Electricity Use in 2030, A. S. G. Andrae, Huawei Technologies, June 2020 (Download PDF)

Approaches to Economizing Power Consumption

CORE EQUIPMENT

Ensure the cleanest and most efficient supply chain (lower environmental impact, more power-efficient manufacturing, using renewable energy where possible).

Repurpose equipment or components where possible.

Upgrade thriftily. Dispose of equipment properly.

TRENDING DOWN 2020-2030

TRANSMISSION

Implement services that enable more data traffic with less equipment. This reduces the need for cooling and power as well as equipment and rack space.

Also, the energy efficiency of networks tends to be best at their core, with customer premises equipment the largest consumer of power.

Purchase and use renewable power where possible, including for backup power.

TRENDING UP MODERATELY

DATA STORAGE

Many of the issues in the transmission category also apply here. Large data centers can be placed in areas with renewable energy options (ex. solar, wind, hydro) or underground.

Datacenter equipment may run hot enough to require water cooling, and this could place significant stress in areas with water-related issues.

TRENDING UP MARKEDLY

EDGE DEVICES

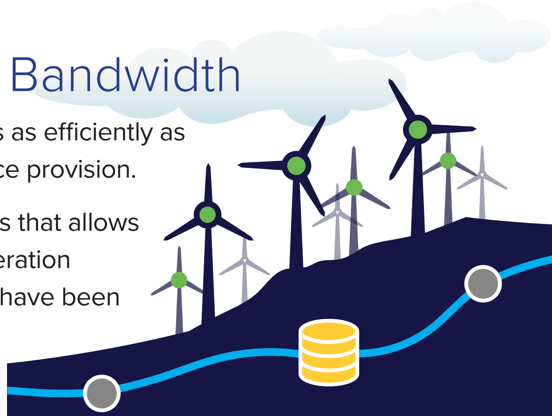
Ensure the cleanest possible supply chain as with Core Equipment, and enable consumers to repair or upgrade devices as needed.

Repurpose equipment or components where possible, and dispose of equipment properly.

Make use of renewable energy sources.

TRENDING LEVEL

CENIC Innovations Improve Energy Use and Bandwidth



Motivated by a desire to scale for the future while using its and its members' resources as efficiently as possible, CENIC has achieved dramatic improvements in power, equipment, and service provision.

CENIC's Spectrum Services is an excellent example of an innovation in Optical Services that allows far more data to be exchanged over a fiber network. It uses only one pair of next-generation transponders to achieve much greater throughput whereas two, three, or more would have been needed previously to achieve less.

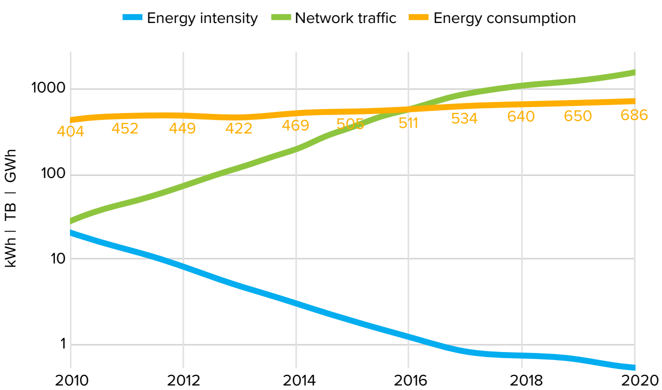
Since air cooling uses so much electrical power, improved airflow also contributes greatly to improved power efficiency. For example, CENIC has implemented standardized hut, rack, and cabling layouts that do not impede airflow, including the placement of hotter-running equipment at the top of racks to avoid heating up any cooler-running equipment above it.

By implementing these and other process-related efficiencies, ***CENIC was able to reduce its power use from 343,000 to 106,000 kWh/month*** – a major cost savings and reduction in power consumption of over two-thirds and the equivalent of powering 270 households while still increasing capacity for its member communities.

Work-from-home options for network staff where possible also minimize commutes and hence fuel consumption. The average fuel mileage is 25.2 mpg in CENIC's home state of California. Assuming 8.89 x 10-3 metric tons of CO2 released per gallon of gas and 394,000 total miles per year not driven by CENIC's thirty-five Network Operations and Engineering staff working remotely during the COVID19 pandemic, this resulted in a savings of over 15,600 gallons of gasoline (and 139 metric tons of CO2) per year.

Another extremely promising area of innovation for data centers is that of enabling the Earth itself to act as a heat sink by means of earth-sheltered or underground construction, which takes advantage of the moderate and stable temperature some 30 meters below the surface along with excellent security and protection from sunlight, severe weather, and even earthquakes. In such environments, air cooling is often more than sufficient even for large data centers, and the land overhead is left available for habitation and renewable energy sources like solar and wind farms.

The Future of Power: Caution and Optimism



Energy intensity (Ussa, 2020; Pihkola et al., 2018, p. 5), network traffic (Traficom, 2021) and energy consumption of mobile networks in Finland, 2010-2020. Energy comsumption has been calculated as the product of energy intensity and network traffic. [2]

In 2010, CENIC used one full rack of equipment for 10 Gbps of data traffic. Today, we can achieve 400 Gbps or more with only 1/24th as much equipment, a major savings of space and power.

It is however important to remember that while energy intensity in terms of kiloWatt-hours per Gigabit (kWh/Gb) has gone well down, data traffic has gone up to the point where power consumption has actually risen slightly. What's more, many growing innovations like blockchain, Artificial Intelligence, and Virtual and Augmented Reality are already proving to be extremely power-intensive.

While the improved efficiencies in network power consumption and services as demonstrated by CENIC are good reason for optimism, we nonetheless cannot achieve a stable and balanced power budget without being mindful of the Jevons paradox first codified in the 1800s – making any equipment more efficient often results in a net increase in power consumption.

In other words, improvements in efficiency alone cannot balance the power budget for networks and will not relieve us of the responsibility to remain mindful of these challenges.

[2] A Comparison of the Energy Consumption of Broadband Data Transfer Technologies, J. Nuutinen, Aalto University, November 23, 2021 (Download PDF)