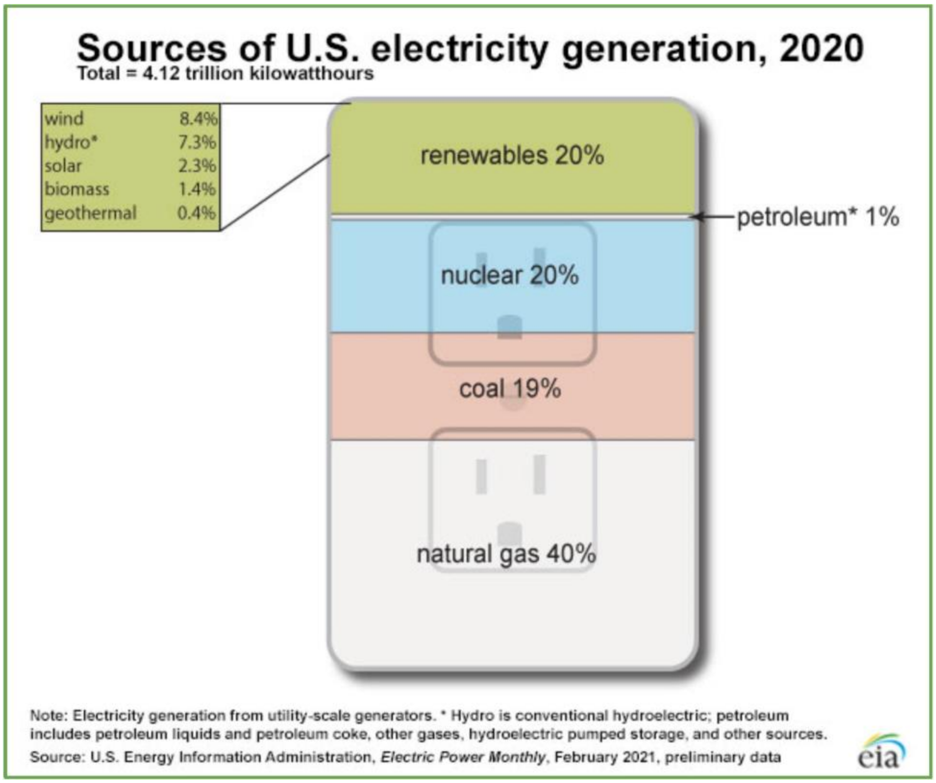
Reducing Your Data Center Carbon Footprint with Bamboo Arm Servers

An Analysis by Kurt Marko for Bamboo Systems

Organizations are increasingly attuned to the fossil fuel usage required to power their internal operations. Regardless of one's view on anthropogenic climate change, no business likes to waste money by running inefficient equipment and since 60 percent of domestic electricity is generated using fossil fuels, the resulting CO2 emissions are significant. With much of the debate centered on the shift to renewable energy sources, lost in the discussion is the enormous energy and carbon savings available from adopting more efficient technologies. Perhaps nowhere in the business world are the efficiency opportunities greater than in the data center, which the IEA estimates (widely recognized as conservative) use about 1 percent of the world's total electricity output.



Source: Electricity in the U.S. - U.S. Energy Information Administration (EIA)

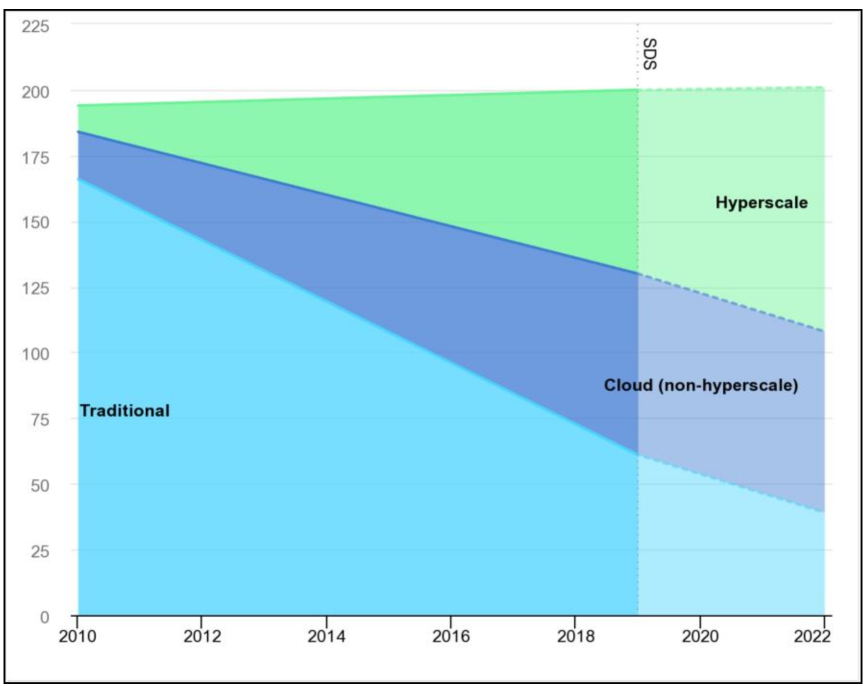
Thanks to the continued miniaturization of silicon components and the aggressive use of renewable energy sources by hyperscale cloud operators, the IT industry has been a bright spot in the effort to reduce CO2 emissions. Despite the incredible growth in data center capacity and performance, energy consumption has only increased a few percent over the past decade. Flat consumption primarily results from the shift to cloud computing and hyperscale operators that have vigorously deployed solar arrays and wind turbines to power their mammoth facilities. Indeed, the IEA calculates that (**emphasis added**),

> *"In 2018, Google (10 TWh) and Apple (1.3 TWh) purchased or generated **enough renewable electricity to match 100% of their data centre energy consumption**. Equinix consumed 5.2 TWh in 2018 (92% renewables) while Facebook data centersconsumed 3.2 TWh (75% renewables)."*

Renewable investments by cloud operators have largely insulated the IT industry from criticism over its carbon footprint. The same can't be said for the cryptocurrency ecosystem, which has been attacked for the inefficiency of Bitcoin mining and resulting CO2 emissions. If the Bitcoin critiques lead to greater societal sensitivity to energy use in the technology industry writ large, data center operators will be under tremendous pressure to improve efficiency and reduce their carbon footprint. At Bamboo Systems, we have a way organizations can deliver the performance modern applications demand with the energy efficiency and CO2 reductions customers and Environmental, Social, and Governance (ESG) investors demand.

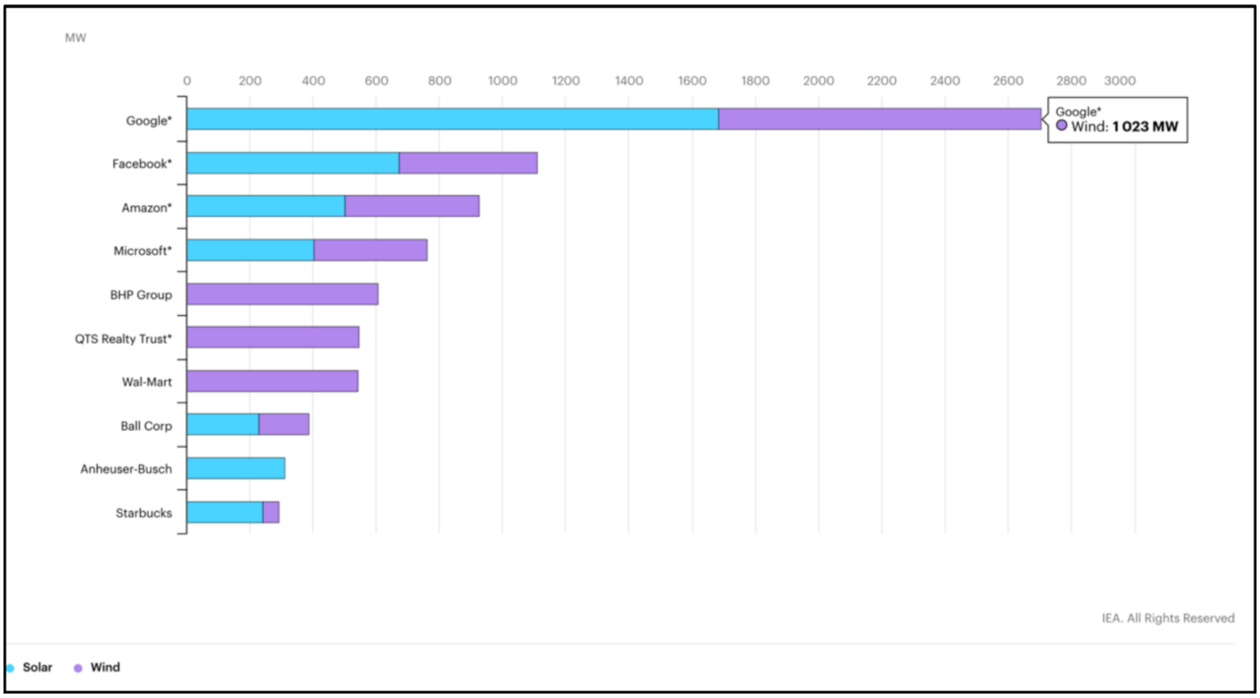
Energy Used in TWh/year by Different Types of Data Centers

Traditional data centers are declining rapidly as cloud and hyperscalersgrow, the latter now constituting 45% of the total.



Source: IEA, Global data centre energy demand by data centre type, 2010-2022, IEA, Paris

Largest Corporate Producers of Renewable Energy



Source: *[IEA, Global data centre energy demand by data centre type, 2010-2022, IEA, Paris]*

Minimizing Energy and CO2 Use in the Modern Data Center

We're all familiar with the adage that today's smartphone has millions of times more computing power than the systems used by NASA during the Apollo lunar landing program. The proximate cause of such computational largess is a decades-long cycle of semiconductor process miniaturization and concomitant Moore's Law improvements in processing performance, storage capacity and device density. A secondary, but no less significant factor in the mobile phone revolution is a processor architecture optimized for efficiency and flexibility. Indeed, smartphones were made possible by the Arm architecture used to power almost all devices since the first iPhone. After many generations of process shrinks and microarchitecture improvements, Arm has become not just a viable platform for servers, but arguably better than x86 systems in many scenarios.

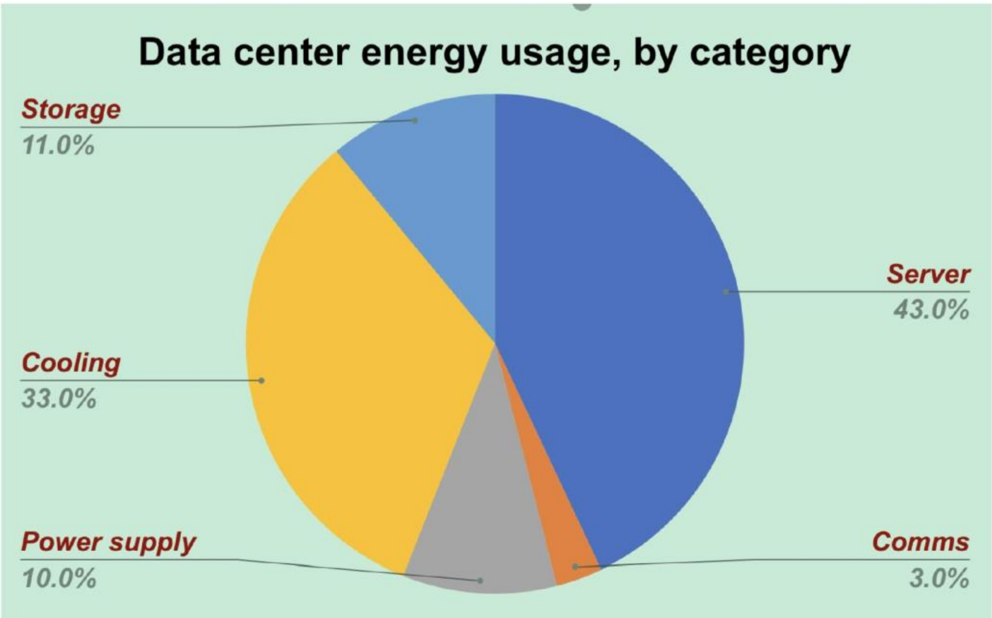
Energy efficiency, often defined by computing performance-per-watt, is one area where Arm systems are indubitably superior to conventional servers. However, until recently, Arm processors could not deliver the baseline performance required of data center workloads. Modern SoCs (systems on a chip) based on Armv8 and future Armv9 designs change the calculus by providing x86-class capabilities in a far more efficient package. The advent of the Arm-based AWS Graviton processors, which by some estimates have already captured 20 percent of the instance share on AWS, demonstrates that Arm can run production workloads while delivering what AWS documents as "up to 40 percent better price performance over comparable current generation x86-based instances for a wide variety of workloads."

To understand the implications on CO2 production from a large data center shifting to Arm servers, we created a model analyzing the many factors contributing to data center energy use. We then calculated the energy savings and translatedit to reduced CO2 emissions based on the fuel mix used to power the electric grid in various locations. Our model shows that an Arm-powered data center reduces CO2 production by 74 percent, equivalent to that in almost half a million barrels of oil. Here's how.

The Model: Radically Efficient Servers Significantly Reduce Power Consumption

Since our contention is that innovative server design can significantly reduce data center energy use, our model uses a server's power draw and physical size as the pivotal factors. After calculating server usage, we can infer the energy needed for other data center subsystems by using ratios derived from our operational experience at Bamboo Systems and validated by estimates fromother data center operators.

Data center energy usage can be subdivided into five primary categories of equipment and facilities infrastructure: servers, network communications, power supplies, conversion and UPS, cooling systems and storage. As the following chart illustrates, servers and cooling comprise about three-quarters of the total.



Source: Energy Innovation, verified by estimates from Bamboo Systems and Ramdas, Shrinath & Rajmane,Pavan & Chauhan, Tushar & Misrak, Abel & Agonafer, Dereje. (2019). Impact of Immersion Cooling on Thermo-Mechanical Properties of PCB's and Reliability of Electronic Packages. 10.1115/IPACK2019-6568.

Our model starts by calculating the energy used by a medium-sized data center with 750 racks of conventional 1U servers, i.e. 42 servers/rack or 31,500 total. If we assume that servers comprise about two-thirds of the floor space and that the equipment space accounts for 65 percent of the total, this translates to a roughly 62,000 square-foot data center. For comparison, hyperscale facilities operated by the major cloud vendors can be a million square feet or more. Knowing server power consumption and the ratios for the various equipment categories, our model uses simple algebra to calculate the energy consumption for each subsystem and the total as follows:

$$Ptotal = Pserver / Kserver$$
$$Kserver = 0.43$$
$$Pstorage = Ptotal * Kstorage$$
$$Kstorage = 0.11$$

…

And so on for the other categories

The data center in our hypothetical example has 31,500 servers and if we use the 912.5W power draw of a Dell R640 as typical of 1U x86 servers, the total server usage in our data center would be:

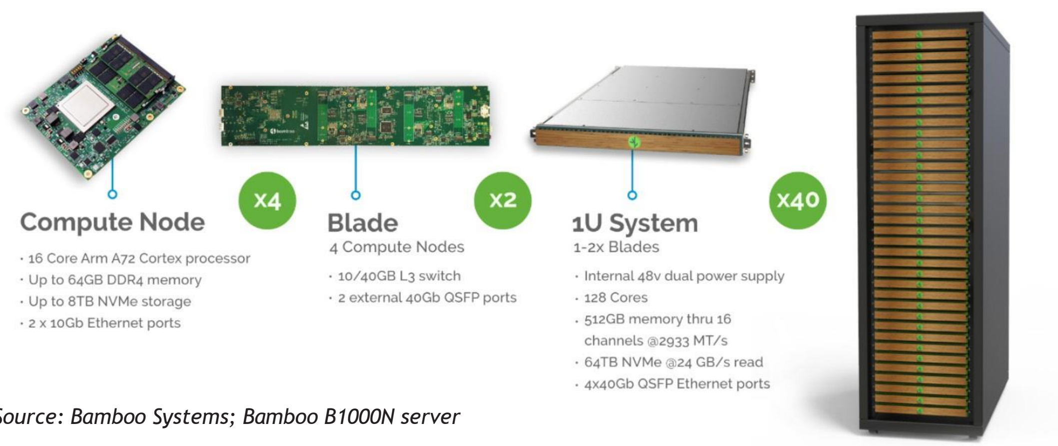
$$0.9125\ kW * 31{,}500\ servers * 8760\ hr/year$$
$$= 251{,}795\ MWh/year$$

From this number, we can derive the usage for each category to be as follows:

Annual Electricity Consumption for 750 rack x86-based Data Center

Category	annual electricity consumption (MWh)
Servers	251,795
Comms	17,567
Power supply	58,557
Cooling	193,238
Storage	64,412
Total	585,570

Using the same formulae, we can calculate the amount saved by using energy-efficient Arm servers; but first, it's critical to understand the differences between the Bamboo Systems B1000N and a standard 1U x86 system. Although both are 1U chassis, the B1000N, incorporates four Arm compute nodes on a micro-blade, with two blades per chassis for eight nodes per server. Each server also requires about one-quarter the electricity of a standard server. However, for modeling purposes, we conservatively assume that a Bamboo installation would require half the equipment racks (375 instead of 750) and 52 percent of the power-per-system. Cranking through the equations yields a data center using only 26 percent as much electricity (152,409 MWh/year) as one based on x86 systems.

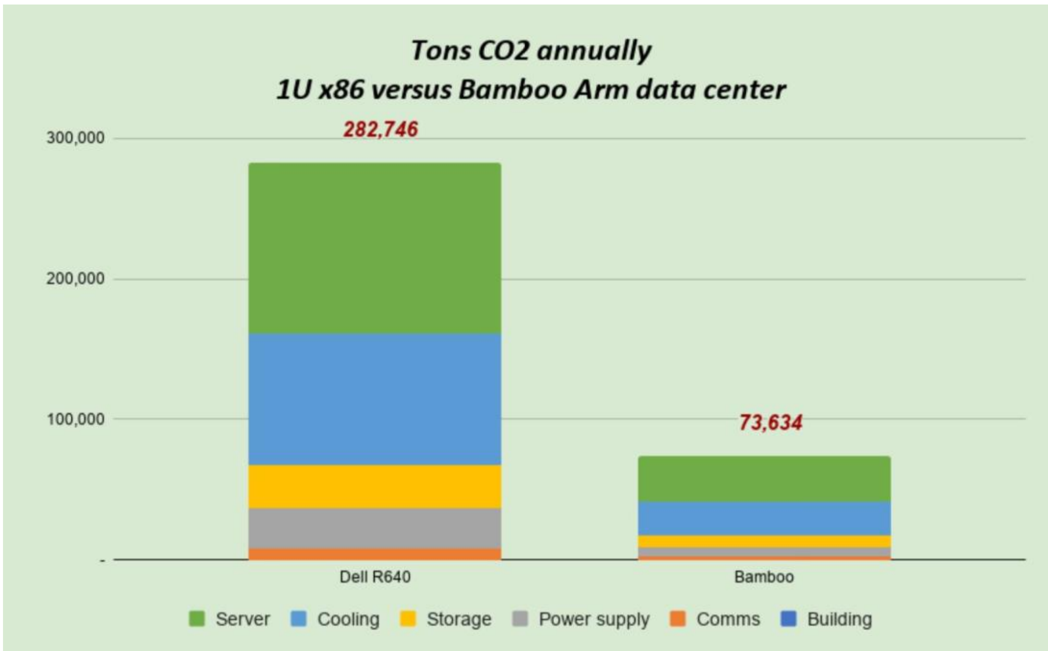


Source: Bamboo Systems; Bamboo B1000N server

Translating Electricity to CO2 Production

Armed with the electric requirements for a conventional versus an Arm-powered data center, we can derive the CO2 emissions from each scenario based on the mix of power sources for electrical generation in different locations. For example, Oregon, where many hyperscale cloud operators have data centers, generates about half of its electricity from hydroelectric generators, with natural gas providing about one-third and non-hydro renewable sources like solar, wind and biomass delivering the rest. In contrast, Virginia, another popular spot for cloud facilities, gets 60 percent of its electricity from natural gas, 30 percent from nuclear power and the rest from renewable sources.

We gathered similar source breakdowns for electrical generation at many other domestic and international locations. We will spare you the math, but for each fuel source, we use published measurements of the mass of CO2 produced per kWh of generated power and calculate a weighted average across locations of ***0.48 kg CO2/kWh***. From this metric, we calculated the annual CO2 produced for each data center scenario. Since Bamboo servers require half the rack space, we also estimate the indirect CO2 emissions used for building materials in each scenario. In total, a hyper-efficient data center using servers from Bamboo Systems produces only ***26 percent as much CO2*** as a conventional facility.



Source: Bamboo Systems estimates

Translating Savings into Everyday Equivalents

Our example of a relatively small data center saving 209 kilotons of CO2 might sound like a big number, but it's meaningless in a vacuum. Only by comparing the savings to the emissions from familiar activities can we judge their true significance. Once again, we did the math and ***each year*** our low-carbon Bamboo data center saves the equivalent of:

45,459
Fewer Cars on the Road

486,749
Less Barrels of Oil Used

367,076
Fewer Passenger Flights from JFK - LHR

4,357
Less Homes Emissions

Aside from the ESG bona fides CO2 reduction gains an organization, emissions cuts might also be valuable in the market for carbon offset trading. According to data from the World Bank, the price of carbon ETS (emissions trading system) credits averages about $20 per ton CO2 . Thus, transitioning our example data center to efficient Arm servers might generate more than ***$4 million annually*** depending upon the jurisdiction and carbon trading requirement.

We believe that there are many technical and economic reasons to adopt energy-efficient servers in cloud data centers, however, an unsung benefit is their potential for being both good for business ***and the environment***. Indeed, we believe that Bamboo Systems is leading the way to the zero-carbon data center.

About Kurt Marko

Kurt is an IT analyst, consultant and regular contributor to a number of technology publications including Diginomica, TechTarget and AvidThink. He specializes in deep technology analysis, consulting and writing for vendors, industry organizations, publications and anyone who needs his brand of **K**een, **R**elevant, **M**eaningful (***KRM***) research, insight and communication. Coming out of Stanford with a BS and MS in Electrical Engineering, Kurt started as an EE developing transistors and fabrication processes, went on to Bell Labs to design integrated circuits, and devolved into an IT architect for HP designing systems and networks. Lately, he's been found analyzing and reporting on all things IT, focusing on cloud infrastructure, services, security and modern applications, with a helping of DevOps tools, automation methods and IoT coverage.