

Bitcoin mining and energy consumption



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Ever since its creation, Bitcoin has come under fire for consuming electricity for its mining processes. Most of these critics sadly do not share their reasoning, sources and calculations, making it hard to verify their claims.



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We need to ban BitCoin because it's fucking our environment and carbon emissions:

uk.businessinsider.com/bitcoin-mining...

348 5:07 PM - Nov 26, 2017

The electricity used to mine bitcoi...

Admittedly, the topic is complicated and full of unknowns. By sharing some of our calculations and assumptions, we hope to make the debate more balanced and productive.



Open pit mining

How much electricity does Bitcoin consume?

As Bitcoin mining is unregulated and in many jurisdictions even illegal, there is no hard data on how much total electricity Bitcoin uses. Even in places where Bitcoin mining is regulated and legal, power companies do not necessarily know what the electricity is used for, and their statistics do not account for cryptocurrency mining.

We can estimate the power, however, by looking at Bitcoin's "difficulty". Difficulty is a number calculated by the Bitcoin protocol and embedded into each Bitcoin block. This difficulty is a measure of how many hashes it takes for a miner to find a valid block on average. It is recalculated every 2016 blocks (roughly two weeks) in order to keep block intervals at roughly 10 minutes.

As of December 7, block 498048, the Bitcoin difficulty stands at 1,590,896,927,258. Each hash is effectively a random number between 1 and $2^{256}-1$. The difficulty describes the target that the hash must undershoot. This is similar to throwing darts randomly at a large target. The difficulty describes the size of the bullseye. The smaller the bullseye, the more often you have to throw a dart to randomly hit the bullseye.

We can calculate the number of hashes you need to compute on average to find a block within ten minutes using the formula $D * 232 / 600$. You can see how this formula is derived here. For the current difficulty, this gives us an estimation of 1.14×10^{19} hashes per second, or 14 Exahash/s.

Bitmain is a manufacturer of Bitcoin mining equipment based in Beijing and Shenzhen. They claim to have produced roughly 70% of the world's Bitcoin miners, using chips from Taiwanese chip foundry TSCM. Their latest model, the S9, uses a 19nm chip. From their website we can learn that the latest batch produces about 14 TH/s (14×10^{12}) at 1372W. Earlier S9 models use the same electricity per hash.

As this is the currently most energy efficient miner on the market, it allows us to calculate a lower boundary for how much electricity is consumed.

Dividing 1.14×10^{19} by 14×10^{12} , we can calculate that there are a maximum number of 800,000 S9 miners currently in operation, consuming roughly 1,100 MW in total. The statistics provided by the International Energy Agency do not use MW or GW. Instead, they use "Mtoe", or "Million tons of oil equivalent". 1 toe is 11.63 MWh. The total energy estimated to be used globally in 2017 is 13,647 Mtoe, or 158,714,610 GWh. In comparison, by today's difficulty standard, we would expect the Bitcoin network to consume roughly 9,636 GWh over an entire year, less than one 16,000th of the global supply.

Bitcoin consumes 1,100 MW in total, that is, 9,636 GWh over an entire year, or 0.829 Mtoe.

This is just a lower boundary, but it is also a relatively good estimate. Some of the miners currently active on the Bitcoin network might be older and less efficient, but already the second most efficient Bitcoin miner generation, the Bitmain S7, consumers 1.5 times as much energy per hash as the S9. While it might be profitable to use this miner with Bitcoin's current rapid price increases, it will not be profitable in the long run.

This lower boundary also serves as a natural equilibrium. If all other variables—like price and technology—remain constant, Bitcoin's energy consumption will converge to this boundary.



Google's data centers consume about double as much electricity in 2015 than Bitcoin consumes in 2017

Why does that seem so small?

There are many ways we can make that number look big or small in comparison, depending on what we want you to think. If I had the intention to lobby for a ban of Bitcoin mining, I would use references like the one below:

- Bitcoin uses as much energy as 520,000 Canadians every day
- Bitcoin uses as much energy as the Democratic Republic of Congo
- Bitcoin uses more energy than 116 countries each
- Bitcoin uses enough energy to power 6 Nimitz-class aircraft carriers

It is also easy to make this number look very small:

- The energy that Bitcoin consumes in a year would only last the U.S. for 19 hours.
- Bitcoin uses only 20% of the energy from a single coal power plant in Taiwan
- The Three Gorges Damn in China produces three times as much electricity as Bitcoin consumes

- The U.S. produces more electricity from a single Geothermal plant than Bitcoin requires
- 17 NSA Data centers together consume more electricity than Bitcoin
- Google used about double as much electricity in 2015 than Bitcoin does today

What does the future of Bitcoin mining look like?

Bitcoin currently consumes mostly very cheap electricity. Miners race to the bottom of who can find the cheapest electricity, and everyone consuming electricity significantly larger than the average is forced to shut down their unprofitable operations.

As a result, Bitcoin mostly consumes electricity in places where it is abundant, cannot be stored or transported. Because oil, gas and coal are often trivial to transport, you very rarely find Bitcoin mining operations that consume these resources, because it would be more profitable to ship the energy to a place where it can be sold for more.

While some coal in landlocked and inaccessible locations is fired up in an environmentally unfriendly process to mine Bitcoins, most miners are powered by hydroelectric dams, geysers and other geothermal energy sources that cannot be transported or stored.

Bitcoin will continue to seek those cheap and otherwise unused forms of electricity, while it will probably never be profitable to mine in urban or industrial centers. You are willing to pay more for your air-conditioning or water heating than a Bitcoin miner can afford.

How much does it cost to mine a Bitcoin?

Miners are rewarded for their efforts with Bitcoin payments. They are willing to only burn as much electricity as they are being given as a reward. Block 498048 (that we look at above) yielded 14.6 BTC as a reward for its miner, a relatively typical fee. This is about US\$230,000 at the current volatile prices. Given a electricity cost at US\$0.02 per kWh and 1,100 MW consumption, a block costs in average 183 MW, or US\$3,600.

If Bitcoin prices remain constant and enough miners can be built, we would expect Bitcoin's electricity consumption to increase five-fold in the short run.

In the long run however, Bitcoin's mining reward will become smaller and smaller. It's base reward (currently at 12.5 Bitcoin per block) will half every four years, until it reaches zero. The reward from transaction fees (currently 2 Bitcoins per block) is expected to stay the same.

How much electricity will be consumed by the Bitcoin network in this case depends on the size of the transaction fees, and the value of a Bitcoin. If a Bitcoin is one day worth US\$1 million, two Bitcoins per block would mean 2 million dollars worth of electricity is destroyed every 10 minutes.

Where will that electricity come from?

Bitcoin will continue to unlock largely inaccessible electricity in the form of hydro, geothermal and solar. Few Bitcoin mines will rely on oil, gas or coal, as these resources are largely exhausted, can easily be transported to areas with higher prices, and are expensive to extract.

Also, one can argue that Bitcoin actually *saves* energy. The world's financial system requires many resources beyond the electricity to run servers. Banks house themselves in tall buildings with air-conditioning, private jet companies fly gold and cash around the world for discreet clients, while printing cash requires cotton farming or even the slaughter of animals.

So is Bitcoin really taking a toll on global energy use? Given Bitcoin mining's trend toward renewable resources, and the fact that traditional banking is not so environmentally friendly, the cryptocurrency may actually have a positive effect on the Earth.

