



News & Highlights

Second-Largest Cryptocurrency Slashes Energy Use

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The year 2022 was a milestone for cryptocurrencies—and not just because investors suffered record losses of more than 2×10^{12} USD and the arrest on fraud charges of the founder of one of the biggest exchanges [1,2]. Last year also stands out because, for the first time, a major cryptocurrency took action to curb its enormous energy appetite. On 15 September 2022, Ethereum, the cryptocurrency with the second highest market capitalization, changed its operating algorithm, cutting its electricity use by more than 99% [3]. Dubbed the Merge, this transformation dispensed with mining, the energy intensive computational process that generates new cryptocurrency tokens for users to spend or trade.

The Merge “was a landmark event for the industry,” said Christian Stoll, co-founder of the Crypto Carbon Ratings Institute, a Dingolfing, Germany-based company that tallies the carbon emissions and energy use of cryptocurrencies. “Ethereum was the cryptocurrency with the second largest carbon footprint after Bitcoin,” he said. “I struggle to think of anything else that has increased its energy efficiency by over 99% in one day,” added Joshua Rhodes, a research scientist at the University of Texas, Austin, TX, USA, who studies the economic impacts of energy policy.

Besides reducing global carbon emissions, the change was also important for another reason, said Alex de Vries, a researcher at Vrije Universiteit Amsterdam in the Netherlands and creator of the website Digiconomist, which tracks energy use by Bitcoin and other cryptocurrency networks. “Technically, it demonstrates that you could do the same thing with Bitcoin.”

Estimates of electricity consumption by cryptocurrency networks vary widely because researchers rely on different accounting methods [4,5]. But these estimates agree that major cryptocurrencies require more energy annually than many countries. According to Digiconomist, for example, in early September 2022—just before Ethereum’s Merge—Bitcoin consumed about 132 TW-h of electricity per year, roughly as much as Sweden [6,7]. Ethereum used less, but its annual consumption was still substantial, between 23 and 77 TW-h [8,9]. Almost all of the more than 500 other cryptocurrencies also depend on electricity-gobbling algorithms [10].

Cryptocurrencies’ hunger for electricity translates into a huge carbon footprint. A “best guess” estimate from the Cambridge Bitcoin Electricity Consumption Index in the United Kingdom, which assumes a mix of renewable and non-renewable energy

sources, puts Bitcoin’s annual carbon dioxide emissions at about 53 million tonne-equivalents, or about 0.1% of the world’s total [11]. Ethereum’s pre-Merge output was lower, around 11 million tonne-equivalents, according to the Crypto Carbon Ratings Institute [8]. Cryptocurrency operations also result in large amounts of electronic waste [12]. A 2021 study by Stoll and de Vries calculated that Bitcoin mining alone generates more than 30 000 tonnes of electronic waste every year, about as much as the Netherlands [13].

Governments have started taking—or at least considering—steps to reduce this environmental toll. As of late 2020, China led the world in cryptocurrency mining, in which computers attempt to solve cryptographic puzzles and earn additional cryptocurrency, but the country banned the practice in 2021 [14]. The move may not have reduced overall emissions, however, since some miners are apparently still operating in secret and many have moved to other countries with dirtier sources of electrical power [15,16]. In 2022, the European Union (EU) considered banning mining and trading cryptocurrencies that depend on the most energy-intensive algorithms [17]. Although the EU did not enact the ban, it did adopt regulations that require companies that trade cryptocurrencies to disclose their environmental impact to buyers [17].

Ethereum’s transformation was not a response to government actions. Even before the cryptocurrency launched in 2015, its founders planned to make it more eco-friendly, but that goal took nearly a decade to achieve [18]. Ethereum is like other cryptocurrency networks in that it maintains a blockchain, a virtual record of transactions [19]. However, almost every other cryptocurrency relies on a mechanism called proof-of-work to confirm blocks, or groups of transactions [19]. Miners—or at least their computers—race to guess the solutions to mathematical problems; winners get to add the transactions to the blockchain and receive a cryptocurrency payout [19]. Because miners are competing against each other, they need to deploy as much computing power as possible—many crypto mining facilities now host thousands of machines (Fig. 1) [18]. “The mining process is machines spitting out random numbers 24/7,” with the Bitcoin network alone generating 300 quintillion guesses every day, said de Vries. The system’s redundancy—most of the computers vying to solve a particular problem lose—makes it wasteful. As a result, one Bitcoin transaction requires about 730 kW-h of energy, whereas one MasterCard transaction in the traditional banking system takes only about 0.7 W-h [6,20].



Fig. 1. This Bitcoin mining facility—Canada's largest—covers about 4.5 ha in Medicine Hat, AB. Drawing more than 63 MW at any given time, the operation consumes roughly the same amount of electricity as the town of Medicine Hat with its population of 63 000. Credit: Wikimedia (CC BY 4.0).

Ethereum could cut its electricity consumption so much because it moved from proof-of-work to an alternative algorithm for verifying transactions called proof-of-stake [18]. Instead of miners, Ethereum now has validators. Users put up some of their own cryptocurrency holdings (a “stake”) for the chance to join this group [19]. If they are selected (at random, but more likely for those with greater stakes), they get to run software that processes transactions and confirms the work of other validators; in return, they receive additional cryptocurrency [21]. Validators do not need warehouses of crypto mining rigs to perform their tasks. A desktop computer or cell phone can run the Ethereum software [21]. Therefore, the network needs only enough electricity to keep users' devices operating, an estimated 2600 MW·h per year [8].

A large amount of money was riding on the success of Ethereum's transformation. At the time of the Merge, its market capitalization was more than 1.98×10^8 USD [8]. Moreover, ether, the Ethereum coin, had become the cryptocurrency of choice for certain types of uses, including digital contracts, said Rhodes. To transfer Ethereum to a proof-of-stake protocol, developers had to create a new blockchain and then mesh it with the original—all without scrambling investors' holdings [22]. “It was like changing out the engine on a plane in midflight,” said Rhodes.

The Merge went smoothly from a technical standpoint. Its apparent success “seems to be proving that digital currencies and blockchains can operate in this way,” said Rhodes. But the long-term economic implications, such as whether ether will remain attractive for investors and digital transactions, are unclear, said Matteo Benetton, an assistant professor of finance at the University of California, Berkeley, CA, USA. Although the value of ether plunged after the switchover, the value of other cryptocurrencies, including bitcoin, also plummeted as investors jettisoned their crypto holdings, a market freefall that pundits dubbed the “crypto winter” [23]. “It is hard to evaluate the impact because of contemporaneous shocks,” Benetton said. One economic consequence is clear, however. The Merge likely put most of the up to one million Ethereum miners out of business. Their rigs are unsuitable for mining bitcoin or most other cryptocurrencies, and the alternatives they can mine provide puny returns [24].

Before the Merge, Ethereum was consuming about the same annual amount of electricity as Ireland, but the changeover does not necessarily mean the world is suddenly using that much less

power, said de Vries. Some of Ethereum's former miners may have sold their computers for other uses that can require large amounts of electricity, such as gaming. And when Ethereum miners moved their rigs out of some facilities, Bitcoin miners moved their rigs in [5].

Cryptocurrencies' need for power will not decline substantially unless Bitcoin reduces its energy demand, but its user community has been resistant to change, said de Vries. However, the industry faces an uncertain future as regulators around the world look to crack down on how it operates [25]. New rules are likely coming that will put further pressure on Bitcoin to switch from proof-of-work, said de Vries. And Ethereum's example shows that “we have the option to do a lot better.”

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