ESTIMATING ENERGY CONSUMPTION OF ETHEREUM NETWORK

Aleksandr IGUMENOV, Ernestas FILATOVAS, Viktor MEDVEDEV, Remigijus PAULAVIČIUS

Institute of Data Science and Digital Technologies, Vilnius University

aleksandr.igumenov@mif.vu.lt

INTRODUCTION

- One of the most pressing challenges facing ***blockchain technology*** today is the ***ever-increasing consumption of electricity*** used for PoW mining.
- However, most of the studies and proposed approaches for estimating energy consumption mainly focus on the energy consumption of the Bitcoin network and ***do not pay enough attention to*** other important blockchain networks, such as ***the Ethereum network***.
- As the data provided by CoinMarketCap (2021) shows (Fig. 1), ***Bitcoin's*** market ***capitalisation is decreasing***, while ***Ethereum is rising*** and now has approximately half of Bitcoin's capitalisation.
- As a result, studying the energy consumption of the Ethereum network is becoming an important area of scientific research.

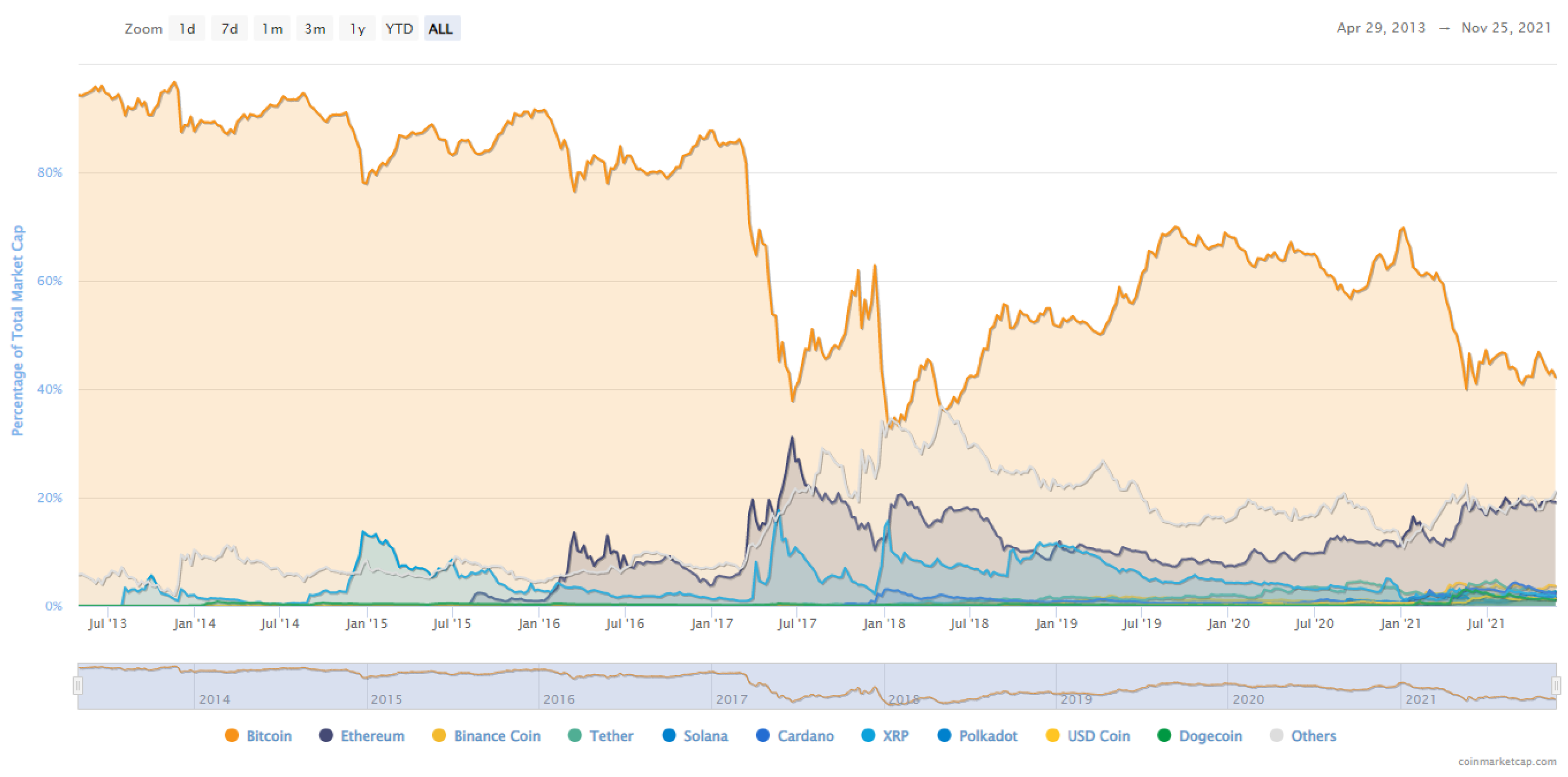

Fig. 1. Major Cryptoassets By Percentage of Total Market Capitalization (CoinMarketCap, 2021)

EXISTING APPROACHES FOR THE ETHEREUM NETWORK ANNUAL ELECTRICITY CONSUMPTION CALCULATION

Study	Novelty	Applicability	Limitations
Krause and Tolaymat (2018)	• An improvement of the Hashrate-based approach proposed by Bevand (2017). • A new approach for calculating the total CO_2 emissions generated by a blockchain network is proposed.	Suitable for PoW-based blockchains, applied for Bitcoin, Ethereum, Litecoin and Monero.	No set of mining equipment is offered, a generalized efficiency factor for mining devices is used.
de Vries (2018) Digiconomist (2021)	• A top-down approach. • An improvement on the approach proposed by Hayes (2015). • Proposed a calculation method for the lower bound and a realistic estimate of energy consumption. • Published the Digiconomist (2021) website.	Suitable for PoW-based blockchains, applied for Bitcoin, Ethereum.	The calculations are based on the economic factors of cryptocurrency mining and, as a consequence, do not take mining equipment into account, which can lead to potentially misleading calculations.
Zade et al. (2019)	• An improvement of the approach proposed by O'Dwyer and Malone (2014). • Modified top-down approach with the energy consumption predictions.	Suitable for PoW-based blockchains, applied for Bitcoin and Ethereum.	A list of the most popular mining equipment selected at a particular point in time is used, but this list is static.
Sedlmeir et al. (2020)	• An improvement of the Hashrate-based approach proposed by Bevand (2017). • A top-down approach.	Suitable for PoW-based blockchains, applied for Bitcoin, Ethereum, Bitcoin Cash, Bitcoin SV, Litecoin.	The calculations are based on the economic factors of cryptocurrency mining and, as a consequence, do not take mining equipment into account, which can lead to potentially misleading calculations.
Gallersdörfer et al. (2020)	• An improvement of the bottom-up Hashrate-based approach proposed by Krause and Tolaymat (2018).	Suitable for PoW-based blockchains, applied for 20 cryptocurrencies.	A static list of the most commonly used equipment is used to derive its efficiency factor.

Fig. 2. Typical GPU Mining Rig

PARAMETERS COMMONLY USED TO ESTIMATE ETHEREUM NETWORK ENERGY CONSUMPTION

Parameter (type)	Description	Measure / Unit	References
Network Hashrate, mean daily (Dynamic)	The mean rate at which miners are solving hashes on the specific day	H/s	Etherscan (2021)
Ethereum issuance value, daily (Dynamic)	Price for Ethereum on the specific day	USD	Etherscan (2021)
Miners rewards, daily (Dynamic)	Total amount of all rewards paid to miners on the specific day	USD	Etherscan (2021)
Difficulty, mean daily (Dynamic)	The mean difficulty of finding a new block on the specific day	-	Etherscan (2021)
Ethereum market price (Dynamic)	The fixed closing price of the asset as of 00:00 UTC on the specific day	USD	Etherscan (2021)
Equipment energy consumption (Static)	The electricity consumption of specific GPU hardware	Watt (W) or J/s	Miningbenchmark (2021)

COMPARISON OF DIFFERENT APPROACHES FOR THE ETHEREUM NETWORK ENERGY CONSUMPTION CALCULATION

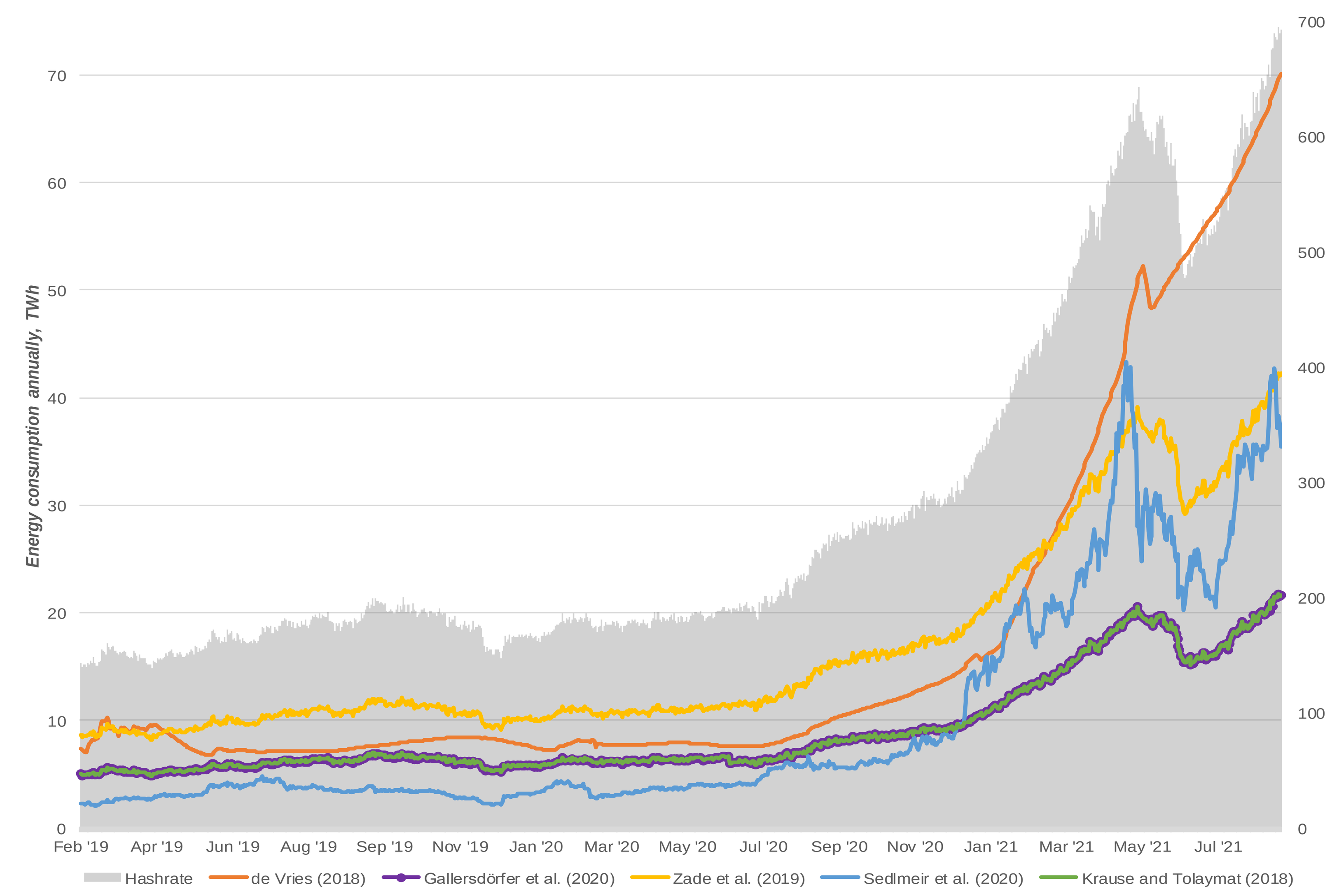

Fig. 3. The Ethereum network annual energy consumption estimation with different approaches

As can be seen from *Fig. 3* different approaches give different results. For example, the results of the Ethereum energy consumption calculations obtained by different methods for the specific date 2021-01-01 can vary significantly: de Vries (2018) - 14.7 TWh, Krause and Tolaymat (2018) - 9.4 TWh, Zade et al. (2019) - 18.0 TWh, Sedlmeir et al. (2020) - 9.49 TWh, Gallersdörfer et al. (2020) - 9.4 TWh.

CONCLUSIONS

- Comparison of the annual Ethereum network energy consumption evaluation revealed that existing approaches produce differing estimates.
- All reviewed methods simplify the actual situation; therefore, there is no approach to precisely calculate the real Ethereum network energy consumption.

REFERENCES

- Bevand, M. (2017). Electricity consumption of bitcoin: a market-based and technical analysis. URL: *https://blog.zorinaq.com/bitcoin-electricity-consumption/*.
- CoinMarketCap (2021). Global Cryptocurrency Market Charts | CoinMarketCap. URL: *https://coinmarketcap.com/charts/* (accessed 25 November 2021).
- de Vries, A. (2018). Bitcoin's Growing Energy Problem, Joule, Volume 2, Issue 5, 801-805. URL: *https://www.sciencedirect.com/science/article/pii/S2542435118301776*. DOI:10.1016/j.joule.2018.04.016.
- Digiconomist (2021). Ethereum Energy Consumption Index - Digiconomist. URL: *https://digiconomist.net/ethereum-energy-consumption* (accessed 20 November 2021).
- Etherscan (2021). Ethereum network charts. URL: *https://etherscan.io/chart/* (accessed 20 November 2021).
- Gallersdörfer, U., Klaaßen, L., Stoll, C. (2020). Energy consumption of cryptocurrencies beyond bitcoin, Joule 4, 1843–1846. URL: *https://pubmed.ncbi.nlm.nih.gov/32838201*, *https://doi.org/10.1016/j.joule.2020.07.013*. DOI:*10.1016/j.joule.2020.07.013*.
- Hayes, A. S. (2015). A cost of production model for bitcoin. URL: *https://www.economicpolicyresearch.org/econ/2015/NSSR_WP_052015.pdf*.
- Krause, M. J., Tolaymat, T.(2018). Quantification of energy and carbon costs for mining cryptocurrencies, Nature Sustainability 1, 711–718.URL: *http://www.nature.com/articles/s41893-018-0152-7*. DOI:*10.1038/s41893-018-0152-7*.
- Miningbenchmark (2021). Mining benchmark - hardware - gpu / asics profitability comparator. URL: *https://www.miningbenchmark.net/* (accessed 10 October 2021).
- O'Dwyer, K. J. and Malone, D. (2014). Bitcoin mining and its energy footprint, in: 25th IET Irish Signals Systems Conference2014 and 2014 China-Ireland International Conference on Information and Communications Technologies (ISSC2014/CIICT 2014), 2014, pp. 280–285. *DOI:10.1049/cp.2014.0699*.
- Sedlmeir, J., Buhl, H. U., Fridgen, G., Keller, R. (2020). The energy consumption of blockchain technology: Beyond myth, Business & Information Systems Engineering 62, 599–608. URL: *https://doi.org/10.1007/s12599-020-00656-x*. DOI:*10.1007/s12599-020-00656-x*.
- Zade, M., Myklebost, J., Tzscheutschler, P., Wagner, U. (2019). Is bitcoin the only problem? a scenario model for the power demand of blockchains, Frontiers in Energy Research 7. URL: *https://www.frontiersin.org/article/10.3389/fenrg.2019.00021. doi:10.3389/fenrg.2019.00021*.