CCRI

NOV 2023

NETWORK ASSESSMENT

CELO

Electricity Consumption
and Carbon Footprint
of the CELO Network

EXECUTIVE SUMMARY

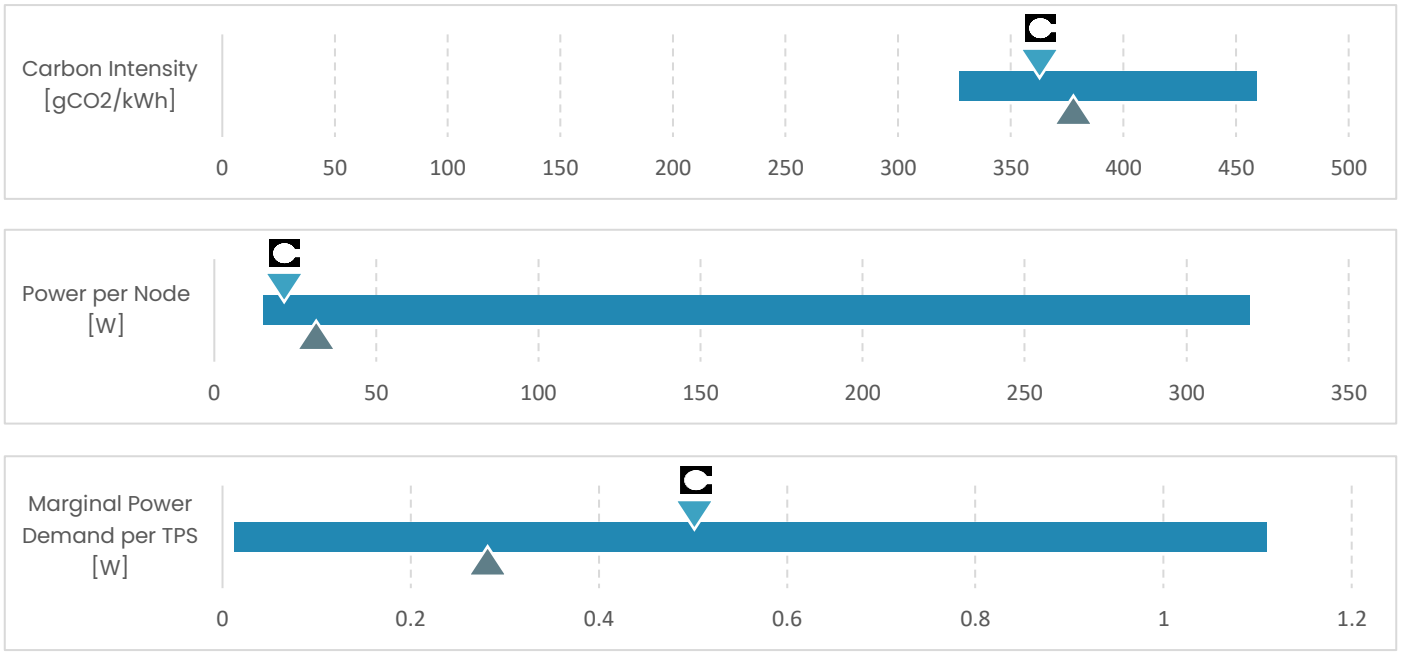
Network Assessment

CELO Blockchain

November 2023

- CELO employs an **energy-efficient Proof of Stake (PoS)** protocol. In comparison to Proof of Work (PoW)-based protocols such as Bitcoin, CELO **consumes significantly less electricity**.
- We find a **total annualized electricity consumption** of 47 MWh for the CELO network as of September 2023.
- Furthermore, we calculated the **carbon emissions** associated with the electricity consumption via location specific **emission factors**, taking the network **node locations** into account.
- For the CELO network, we find a **total annualized carbon footprint of 17.21 tCO_2e** at a carbon intensity **of 367 gCO_2 per kWh**.
- The **marginal power demand** per TPS (transactions per second) in the CELO network amounts to **0.55 W**.
- Compared to other PoS networks, CELO performs **slightly above average** in carbon intensity and power demand per node. Due to lower number of transactions, the **marginal power demand per transaction is below average**.
- In this assessment, we have focused on **the core CELO network**, comprising **validators**, and have not included emissions from ancillary activities like testnets or corporate operations.

SELECTED BENCHMARKING RESULTS



Legend: indicates the range, CELO's performance and median value of the peer group*.

*Peer group consists of Algorand, Avalanche, Cardano, Cosmos, Ethereum, Polkadot, and Solana, which have been assessed in the latest CCRI PoS Benchmarking Study. Available here: https://carbon-ratings.com.

METHODOLOGY

The analyses underlying this factsheet follow the same approach and methodology as outlined in CCRI's methods whitepaper for assessing the electricity consumption and carbon footprint of PoS networks.[1]

There are five main steps:

1	**HARDWARE SELECTION**	We analyze the network and its minimum hardware requirements and select the hardware sample that we use to measure a single node's electricity consumption.
2	**HARDWARE MEASUREMENT**	We run a full node on all selected hardware devices and measure their electricity consumption to calculate a best-guess estimate for the average network node while accounting for the hardware distribution.
3	**TOTAL NETWORK ELECTRICITY CONSUMPTION**	We estimate the electricity consumption of the entire network by scaling the electricity consumption with the total network node count.
4	**MARGINAL ELECTRICITY CONSUMPTION**	We examine the number of transactions handled during the measurement period and derive the marginal electricity consumption per transaction.
5	**CARBON INTENSITY AND FOOTPRINT**	We gather data on the node locations[2] of the network and use regional emission factors to calculate the network specific carbon intensity. We use this carbon intensity to translate the network's electricity consumption into a carbon footprint.

[1] CCRI (2022). Determining the electricity consumption and carbon footprint of Proof-of-Stake networks. https://carbon-ratings.com/dl/whitepaper-pos-methods-2022

[2] We derive location data from https://thecelo.com.

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Results

CELO: Electricity Consumption and Carbon Footprint
(all metrics as of September 28, 2023)

The analyses underlying this factsheet are commissioned by ***Climate Collective***

KEY NETWORK METRICS

Name	Celo
Symbol	CELO
Consensus mechanism	Proof of Stake
Network type	Layer 1
Validator count	220[3]
24h-analysis-period transaction count	201,937
Annualized transaction count	73,707,005

KEY FINANCIAL METRICS

Market capitalization (rank) [USD]	231,031,231.81 (#116 according to CoinMarketCap)
Market price [USD]	0.4514
Circulating supply [CELO]	511,790,944
0024 hours trading volume [USD]	10,115,684.54

KEY ELECTRICITY METRICS

Average electrical power per node [W]	24.33[4]
Electrical power of network [W]	5,352.60
Annualized electricity consumption [kWh]	46,896.94
Marginal power consumption per TPS [W]	0.54900423

KEY CARBON METRICS

Annualized CO_2 emissions [tCO_2]	17.21
Marginal CO_2 emissions per tx [g CO_2]	0.05597
Applied CO_2 emission intensity [g CO_2/kWh]	367.00

[3] CELO defines in its documentation two running nodes (with slightly deviating configurations) per validator; therefore, we multiply the number of validators (110) times 2.
[4] Value for a representative node assuming the node distribution among hardware configurations as shown in the Appendix.

Appendix

HARDWARE-SPECIFIC MEASUREMENT RESULTS

Hardware configuration	1	2	3	4	5	6
CPU	Broadcom BCM2711	Intel i3-8109U	Intel i5-8400T	Intel i5-1135G7	Intel i5-10400	AMD 3970X
Ram	8 GB	8 GB	8 GB	16 GB	64 GB	256 GB
Storage	128 GB SD	512 GB SSD	256 GB SSD	2 TB SSD	2 TB SSD	2 TB SSD
Configurations selected	no	no	yes	yes	yes	yes
Mean electrical power in idle [W]	3.031	2.688	2.893	3.675	25.304	80.464
Mean electrical power of node [W]	-	-	5.380	5.704	26.371	93.068
Assumed node distribution	-	-	12.5 %	37.5 %	37.5 %	12.5 %
Measurement period	2023-09-28 14:09 CET to 2023-09-29 14:09 CET					
Software version	Geth: 1.8.0-stable; Docker image: 2b11ce94fc27					

About CCRI

CCRI – *Crypto Carbon Ratings Institute* – is a research-driven company providing data on sustainability aspects of cryptocurrencies, blockchain and other technologies. The interdisciplinary team has built a multi-year research track record with a specific focus on cryptocurrencies and their sustainability impacts. CCRI uses the most up-to-date data sources as well as methods based on formerly peer-reviewed studies published in renowned scientific journals. CCRI provides insights that help their clients to understand and manage crypto-related ESG exposure. They serve a broad range of clients including institutional investors, exchanges and blockchain networks.