Mandatory information on principal adverse impacts on the climate and other environment-related adverse impacts of the consensus mechanism

N	Field	Content
General Information		
S.1	**Name**	Zillion Bits Ltd
S.2	**Relevant legal entity identifier**	254900FESD7AF56FOQ37
S.3	**Name of the crypto-asset**	Ethereum (ETH)
S.4	**Consensus Mechanism**	Ethereum operates on a Proof of Stake (PoS) consensus mechanism since "The Merge" in 2022, replacing its original Proof of Work system. This transition significantly reduced the network's energy consumption while maintaining security and decentralisation. In Ethereum's PoS system, validators who have staked at least 32 ETH are randomly selected to propose and validate new blocks, with their influence proportional to the amount of ETH they have staked rather than computational power. The consensus process begins with validators being organised into committees to streamline validation. When selected to propose a block, a validator collects pending transactions, packages them into a block, and broadcasts it to the network. Other validators then attest to the validity of this block through a voting process. Once a sufficient number of attestations are collected (a supermajority of validators), the block is considered part of the canonical chain. Ethereum's PoS implementation uses a mechanism called Casper FFG (Friendly Finality Gadget) to achieve finality, meaning that once a block is finalised, it cannot be reverted without an extraordinary consensus breach. Validators vote on checkpoint blocks, and once a supermajority agrees, these checkpoints become finalised. This provides strong security guarantees while consuming only a fraction of the energy required by the previous Proof of Work system.
S.5	**Incentive Mechanisms and Applicable Fees**	Ethereum operates on a Proof of Stake (PoS) consensus mechanism that incentivises validators through a structured reward system. Validators earn rewards for their contributions

		to network security through block proposal and attestation activities. These rewards consist of newly minted ETH and transaction fees from validated blocks. The reward rate is dynamic, adjusting based on the total amount of ETH staked in the network. As more ETH is staked, individual reward rates decrease, creating a self-balancing mechanism that maintains network security while regulating participation incentives. Transaction fees on Ethereum follow a model implemented through Ethereum Improvement Proposal (EIP), which introduced a two-component fee structure. The first component is a base fee that adjusts dynamically according to network demand and is burned (removed from circulation), reducing the overall ETH supply over time. The second component is an optional priority fee or "tip" that users can include to incentivise validators to process their transactions more quickly. This fee structure helps stabilise transaction costs while providing validators with additional incentives for efficient transaction processing. Validators face penalties for malicious behaviour or extended inactivity, creating a robust security framework. The slashing mechanism results in the loss of a portion of staked ETH for validators who engage in dishonest activities such as double-signing or validating incorrect information. Additionally, validators incur inactivity penalties if they remain offline for extended periods. These economic disincentives ensure that validators remain active and honest, maintaining the network's security and operational integrity. Smart contract interactions on Ethereum incur gas fees proportional to their computational complexity and size. Each operation on the Ethereum Virtual Machine (EVM) has an associated gas cost, with more complex operations requiring more gas. Deploying new smart contracts typically costs more than simple interactions with existing contracts due to the storage requirements. Developers are incentivised to optimise their smart contracts to minimise gas usage, making transactions more cost-effective for users. Similarly, transferring ERC-20 or other token standards involves gas fees that vary based on the token's contract implementation and current network demand, with all fees paid in ETH.
S.6	**Beginning of the period to which the disclosure relates**	2024-01-01
S.7	**End of the period to which the disclosure relates**	2024-12-31
	Mandatory key indicator on energy consumption	

S.8	**Energy consumption (kWh/year)**	2368143.36000
	Sources and methodologies	
S.9	**Energy consumption sources and Methodologies**	The methodology for calculating Ethereum's energy follows a top-down economic approach, focusing on the essential energy required for transaction validation and distributed ledger maintenance. Our approach begins by identifying the minimum validator infrastructure necessary for network security. For each validator, we estimate an average power consumption based on hardware specifications from the International Energy Agency's report on data centre energy efficiency and the European Commission's Code of Conduct for Energy Efficiency in Data Centres. The calculation incorporates three primary components: base validation energy, network overhead, and transaction processing energy. Base validation energy represents the fundamental power required by the minimum validator set operating continuously throughout the year. Network overhead accounts for additional energy consumed by peer-to-peer communication, block propagation, and redundancy mechanisms, estimated at 25% of base validation energy based on distributed systems research from the Institute of Electrical and Electronics Engineers (IEEE) publications. Transaction processing energy represents the incremental power required specifically for validating and processing network transactions. For 2024, this component is estimated at 40% of base validation energy, reflecting increased transaction volumes and computational complexity compared to previous years. This estimation draws on transaction volume data from the Ethereum blockchain and energy scaling models published by the International Renewable Energy Agency. The methodology assumes validators operate on energy-efficient hardware optimised for validation tasks, with power consumption measured at the incremental level required for validation rather than total host system consumption. The geographic distribution of validators is considered through weighted regional energy factors based on validator concentration data from network monitoring services. Annual energy consumption is calculated by multiplying the number of validators by their average power consumption and annual operating hours, then adding the network overhead and transaction processing components. This approach provides

		a comprehensive assessment of Ethereum's energy footprint while focusing specifically on the energy directly attributable to blockchain operations.

Supplementary information on principal adverse impacts on the climate and other environment-related adverse impacts of the consensus mechanism

	Supplementary key indicators on energy and GHG emissions	
N	**Field**	**Content**
S.10	**Renewable energy consumption (percentage of the total amount of energy used per calendar year)**	26.35160
S.11	**Energy intensity (energy used per validated transaction in kWh)**	0.01169
S.12	**Scope 1 DLT GHG emissions – Controlled (in t CO2eq per year)**	0.00000
S.13	**Scope 2 DLT GHG emissions – Purchased (in t CO2eq per year)**	2181.31236
S.14	**GHG intensity (emissions per validated transaction in kg CO2eq)**	0.00477
	Sources and methodologies	
S.15	**Key energy sources and methodologies**	For determining the renewable energy consumption percentage, we employ a geographical distribution analysis of Ethereum's validator network. This process begins with mapping the global distribution of validator nodes through IP geolocation data, self-reported locations from validator operators, and node distribution analysis from blockchain analytics platforms. Once the geographical distribution is established, we overlay this information with regional renewable energy mix data obtained from authoritative sources including the International Energy Agency (IEA), the European Environment Agency (EEA), national renewable energy reports, and regional electricity grid authorities. The renewable energy percentage is then calculated as a weighted average, where each region's validator percentage is multiplied by its corresponding renewable energy percentage in the electricity mix.

		For calculating energy intensity, we implement a bottom-up approach focused on the actual energy-consuming components of the Ethereum network. This methodology first establishes the network boundaries by defining the scope to include only the Ethereum mainnet, encompassing both validator nodes and full nodes that maintain the network. We determine the node count by analyzing the number of active validators and estimating the number of physical validator servers based on the assumption that each physical server typically runs multiple validators. We also include non-validator full nodes that maintain copies of the blockchain but don't participate in consensus. The energy consumption calculation incorporates power measurements for different node types, based on the minimum hardware requirements for running Ethereum clients. These figures are multiplied by the number of respective nodes, operational hours, and days in the year to derive the total annual energy consumption. The transaction count is determined through blockchain data analysis, considering all validated transactions on the Ethereum network during the reporting period. The energy intensity is then calculated by dividing the total energy consumption by the total number of transactions processed. Key assumptions in our methodology include the validator-to-server ratio, the power consumption of different node types, and the geographic distribution of validators. We acknowledge certain limitations, such as potential fluctuations in node distribution throughout the year, variations in hardware efficiency among node operators, and the simplified attribution of energy consumption equally across all transactions despite some energy being used for network maintenance regardless of transaction volume.
S.16	**Key GHG sources and methodologies**	The foundation of our GHG emissions calculation begins with the geographical distribution analysis of Ethereum's validator network. We determine the locations of validator nodes through a combination of IP geolocation data, self-reported validator locations, and node distribution analysis from blockchain analytics. This geographical mapping is essential as emission factors vary significantly by region due to differences in electricity generation sources. Once we establish the distribution pattern, we overlay this information with carbon intensity data from authoritative sources, including the International Energy Agency (IEA), the European Environment Agency (EEA), national environmental protection agencies, and regional electricity grid authorities. For calculating the emissions, we employ the location-based method as recommended by the Greenhouse Gas Protocol for Scope 2 emissions. This approach reflects the average

		emissions intensity of grids where energy consumption occurs. We multiply the energy consumption in each region by its corresponding grid-average emission factor to determine regional emissions, then aggregate these values to calculate the total network emissions. This method provides a comprehensive view of the emissions associated with the purchased electricity used by validators across different geographical locations. Scope 1 DLT GHG emissions for Ethereum can be considered negligible because Ethereum's Proof of Stake consensus mechanism relies entirely on validators that consume electricity rather than directly emitting greenhouse gases. The GHG intensity calculation builds upon this emissions data by establishing a relationship between total emissions and network activity. We determine the total number of validated transactions during the reporting period through blockchain data analysis, then divide the total emissions by this transaction count. This provides a measure of the carbon footprint per transaction, offering a standardised metric for comparing environmental impact over time. Our methodology incorporates several key assumptions that warrant acknowledgement. We assume that validators use grid electricity rather than dedicated renewable energy sources unless specific evidence indicates otherwise. We also assume a consistent validator-to-server ratio throughout the network, which may not perfectly reflect the heterogeneous nature of validator setups. Additionally, we attribute emissions equally across all transactions, which simplifies the complex relationship between network maintenance and transaction processing. The methodology accounts for temporal variations by using annual average emission factors, though we recognise that both validator distribution and grid carbon intensity can fluctuate throughout the year. We also acknowledge that the transition from centralised staking services to individual validators may impact the geographical distribution over time, potentially affecting the overall emissions profile. By adhering to established carbon accounting principles while adapting them to the unique characteristics of Ethereum's Proof of Stake network, our methodology provides a robust framework for assessing the greenhouse gas emissions associated with the operation of the Ethereum blockchain, enabling transparent environmental impact disclosure.