Sources and Methodology for Environmental Impact Disclosures under Regulation (EU) 2023/1114

Supporting Disclosures in Sections S.9, S.15–S.16, and S.33–S.36 on Energy Use, Emissions, Waste, and Resource Impacts

Version: 1.0

Date: July 2025

Purpose: This document outlines the sources and methodologies used to assess and disclose the principal adverse impacts on the climate and other environment-related impacts of consensus mechanisms, in accordance with the disclosure obligations under Regulation (EU) 2023/1114. These apply to crypto-asset white papers and disclosures on websites of crypto-asset service providers across all types of crypto-assets.

Regulatory Basis for Adverse Environmental Impact Disclosures

This methodology is developed in accordance with the following regulatory instruments:

- **Regulation (EU) 2023/1114 of the European Parliament and of the Council**
  Establishes a framework for crypto-asset issuance and service provision, including sustainability disclosures.
- **Commission Implementing Regulation (EU) 2024/2984**
  Implementing technical standards for white paper templates under Regulation (EU) 2023/1114. Defines the standardised forms, templates, and field references for crypto-asset white papers, which link directly to the sustainability indicators.
- **Commission Delegated Regulation (EU) [forthcoming], C(2024) 8782 final**
  Adopted on 17 December 2024, this act sets out Regulatory Technical Standards (RTS) specifying the content, presentation, and methodology for environmental indicators under MiCA.
- **ESMA Final Report (ESMA75-453128700-1229) – 3 July 2024**
  Includes the draft RTS prepared by ESMA in cooperation with EBA, forming the basis for the Delegated Regulation and introducing structured indicators (S.1–S.36) across Tables 2, 3, and 4.

These regulatory instruments collectively establish environmental disclosure requirements applicable to issuers of other crypto-assets, asset-referenced tokens, e-money tokens, and crypto-asset service providers, as specified under Articles 6(12), 19(11), 51(15), and 66(6) of Regulation (EU) 2023/1114.

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Abbreviations

ART
Asset-referenced token.

CASP
Crypto-Asset Service Provider.

Delegated Regulation
Commission Delegated Regulation (EU) (forthcoming), C(2024) 8782 final.

DTI
Digital Token Identifier (as provided by Digital Token Identifier Foundation).

EJ
Exajoules

EMT
Electronic money token.

ESG
Environmental, Social and Governance.

ESMA Final Report
ESMA Final Report (ESMA75-453128700-1229) – 3 July 2024.

Implementing Regulation
Commission Implementing Regulation (EU) 2024/2984.

kWh
kilowatt hours

MiCA
Regulation (EU) 2023/1114 of the European Parliament and of the Council.

$MtCO_2e$
Million tonnes CO_2 equivalent.

RTS
Reporting Technical Standards as developed by ESMA.

Definitions

asset-referenced token

A type of crypto-asset that is not an electronic money token and that purports to maintain a stable value by referencing another value or right or a combination thereof, including one or more official currencies, Article 3(1)(6) MiCA.

climate and other environment-related indicators

The indicators listed in the section ‘Mandatory key indicator on energy consumption’ of Table 2 of the Annex, in the section ‘Supplementary key indicators on energy and GHG emissions’ of Table 3 of the Annex, and in the section ‘Optional indicators’ of Table 4 of the Annex.

consensus mechanism

The rules and procedures by which an agreement is reached, among DLT network nodes, that a transaction is validated, Article 3(1)(3) MiCA.

crypto-asset

A digital representation of a value or of a right that is able to be transferred and stored electronically using distributed ledger technology or similar technology, Article 3(1)(5) MiCA.

crypto-asset service

Any of the following services and activities relating to any crypto-asset, Article 3(1)(16) MiCA:

(a) providing custody and administration of crypto-assets on behalf of clients;
(b) operation of a trading platform for crypto-assets;
(c) exchange of crypto-assets for funds;
(d) exchange of crypto-assets for other crypto-assets;
(e) execution of orders for crypto-assets on behalf of clients;
(f) placing of crypto-assets;
(g) reception and transmission of orders for crypto-assets on behalf of clients;
(h) providing advice on crypto-assets;
(i) providing portfolio management on crypto-assets;
(j) providing transfer services for crypto-assets on behalf of clients;

crypto-asset service provider

A legal person or other undertaking whose occupation or business is the provision of one or more crypto-asset services to clients on a professional basis, and that is allowed to provide crypto-asset services in accordance with Article 59, Article 3(1)(15) MiCA.

distributed ledger

An information repository that keeps records of transactions and that is shared across, and synchronised between, a set of DLT network nodes using a consensus mechanism, Article 3(1)(2) MiCA.

distributed ledger technology (DLT)

A technology that enables the operation and use of distributed ledgers, Article 3(1)(1) MiCA.

DLT network node

A device or process that is part of a network and that holds a complete or partial replica of records of all transactions on a distributed ledger, Article 3(1)(4) MiCA.

energy from renewable sources (renewable energy)

Energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas, Article 2(1) Directive (EU) 2018/2001.

electronic money token (e-money token)

A type of crypto-asset that purports to maintain a stable value by referencing the value of one official currency, Article 3(1)(7) MiCA.

greenhouse gas (GHG) emissions

Emissions of gases listed in Part 2 of Annex V to Regulation (EU) 2018/1999 of the European Parliament and of the Council expressed in tonnes of CO2-equivalent.

hazardous waste

hazardous waste as defined in Article 3, point 2, of Directive 2008/98/EC

natural resources

Natural resources as defined in Table 2 of Annex II to the Commission Delegated Regulation (EU) 2023/2772.

non-recycled waste

Any waste not recycled within the meaning of 'recycling' in Article 3, point 17, of Directive 2008/98/EC of the European Parliament and of the Council.

scope 1 DLT GHG emissions

GHG emissions generated from sources that are controlled by the DLT network nodes applying the consensus mechanism, Article 1(d) Delegated Regulation.

scope 2 DLT GHG emissions

GHG emissions from the consumption of purchased electricity, steam, or other sources of energy generated upstream from the DLT network nodes applying the consensus mechanism, Article 1(e) Delegated Regulation.

scope 3 DLT GHG emissions

All indirect GHG emissions that are not covered by points (f) and (g) that occur in the value chain of the DLT network nodes applying the consensus mechanism, including both upstream and downstream emissions, Article 1(e) Delegated Regulation

waste

waste as defined in Article 2, point (23), of Directive (EU) 2018/2001.

waste electrical and electronic equipment (WEEE)

Waste electrical or electronic equipment as defined in Article 3(1), point (e), of Directive 2012/19/EU of the European Parliament and of the Council.

incentive structure

The set of incentives and penalties established as part of a consensus mechanism to economically incentivise distributed ledger technology (DLT) network nodes to co-operate in applying the rules and procedures of the consensus mechanism for the purpose of validating transactions in cryptoassets, Article 1(a) Delegated Regulation.

official currency

An official currency of a country that is issued by a central bank or other monetary authority, Article 3(1)(8) MiCA.

utility token

A type of crypto-asset that is only intended to provide access to a good or a service supplied by its issuer, Article 3(1)(9) MiCA.

Contents

Section 1 – Introduction

Purpose of this Document

This document outlines the sources and methodologies used to support the disclosure of principal adverse impacts on the climate and other environment-related factors arising from the operation of consensus mechanisms in distributed ledger technology (DLT) networks. It is designed to accompany disclosures required under Regulation (EU) 2023/1114 (MiCA) and its associated technical standards, supporting both crypto-asset white papers and website-based disclosures by crypto-asset service providers (CASPs).

It provides the methodological foundation for completing the "Sources and Methodologies" sections of the disclosure templates (fields `S.9`, `S.15`, `S.16` across Tables 2, 3, and 4 of the Delegated Regulation, ensuring the rigour, transparency, and comparability required by law.

External Data Provider Requirements

As an external data provider, Archax supports entities in meeting their sustainability-related disclosure obligations under MiCA. Where estimates or third-party data are used in lieu of direct measurements - as permitted under Article 6(7)–(8) of the Delegated Regulation - the "Sources and Methodologies" section must disclose the name of the data provider, relevant methodologies, assumptions, and, where applicable, a hyperlink to the provider's website.

This ensures transparency and accountability in the use of best-efforts estimates, particularly where direct data from DLT nodes is unavailable or incomplete.

> **Note:** This document constitutes the external data provider's "Sources and Methodologies" disclosure and will be made publicly available via a hyperlink, in accordance with Article 6(8)(c) of the Delegated Regulation.

Model Assumptions and Validation

This section sets out the overarching documentation standards, model construction principles, and methodological assumptions that underpin the disclosures supported by this document. It aligns with the regulatory expectations laid down in Article 6 of the Delegated Regulation and ESMA's technical guidance.

Environmental disclosures under MiCA must be:

- **Rigorous and systematic:** The methodologies must be consistently applied, reproducible, and based on sound technical reasoning.
- **Objective and validatable:** Indicators must be supported by verifiable assumptions, using transparent and auditable data pipelines.
- **Continuously applied:** Disclosures should reflect up-to-date information using methodologies applied at regular intervals. Archax's model is updated weekly and recalibrated as new data or network developments arise.

Where indicators rely on estimated data, Article 6(7)–(8) of the Delegated Regulation permits best-effort use of external sources. This document details:

- The estimation methods used.
- Any relevant datasets.
- Assumptions or extrapolations made where data is incomplete or underreported.

This methodological documentation aims to ensure transparency, comparability, and traceability of disclosed metrics - providing a consistent evidentiary base across all supported crypto-asset types and disclosure channels.

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Scope of Application

This methodology supports environmental impact disclosures under MiCA for both:

- **Disclosure Channels**:
  - Crypto-asset white papers (pursuant to Articles 6, 19, and 51 of MiCA)
  - CASP websites (pursuant to Article 66 of MiCA)
- **Crypto-asset Types**:
  - Other crypto-assets
  - Asset-referenced tokens (ARTs)
  - E-money tokens (EMTs)

Crypto-asset Whitepapers

The Implementing Regulation sets expectations for reporting formats in whitepapers for all crypto-asset types. In the context of environmental impact disclosures, Information on the sustainability indicators in relation to adverse impact on the climate and other environment-related adverse impacts

Crypto-Asset Type	Applicable Template	Section	Specific Subsection
Other crypto-assets	Table 2	Part J – Sustainability indicators	J.1 – Adverse impacts
Asset-referenced tokens (ARTs)	Table 3	Part H – Sustainability indicators	H.1 – Adverse impacts
E-money tokens (EMTs)	Table 4	Part G – Sustainability indicators	G.1 – Adverse impacts

Each of these sections requires the use of specific field references (e.g. `S.1–S.36`), as detailed in Section 2 - Reporting Framework and Standards.

CASP Website Disclosures

In accordance with Article 66(5) of MiCA, crypto-asset service providers (CASPs) must disclose the principal adverse impacts on the climate and other environment-related factors arising from the consensus mechanism used to issue each crypto-asset for which they provide services. Where available, this information may be sourced directly from the relevant crypto-asset white paper.

These disclosures must:

- Use the same field structure as in white papers (`S.1–S.36`), depending on thresholds and proportionality of energy consumption.
- Follow the presentation and methodological requirements set out in the Delegated Regulation.
- Be made available by the crypto-asset service provider in downloadable form, updated at least annually, and provided free of charge by the CASP.

Networks and Tokens

Distributed ledger technologies (DLTs) underpin the networks covered in this document. A DLT network refers to a system of nodes that maintain a shared, synchronised distributed ledger - an information repository recording transactions - by following a predefined consensus mechanism, which governs how agreement on transaction validity is achieved across nodes.

Each supported network represents a distinct DLT implementation, operating under its own consensus rules and infrastructure. These networks serve as the foundational layer on which crypto-asset tokens operate.

Supported Networks

Network	Ticker	DTI Code
Solana	SOL	6QZ1LNC12
Ethereum	ETH	D5RG2FHH0
Binance Smart Chain	BNB	HWRGLMT9T

DTI Code = Digital Token Identifier (Functionally Fungible Group)

> **Note:** Additional networks are currently under active review as part of ongoing efforts to expand coverage to 25+ networks. We are working through client requests and will update this list as new networks are validated.

Supported Tokens

Approximately 7,500 crypto-asset tokens are currently supported across the listed networks. Token-level disclosures rely on and inherit the consensus characteristics and environmental footprint of the underlying DLT on which the token is issued.

Section 2 - Reporting Framework and Standards

The description and reporting sections used for this disclosure are provided in this section. The Implementing Regulation and ESMA Final Report set reporting expectations for disclosure sections `S.1` - `S.36` laid out herein. The structure of reporting is consistent in both disclosure channels of:

- Crypto-asset white papers (pursuant to Articles 6, 19, and 51 of MiCA)
- CASP websites (pursuant to Article 66 of MiCA)

Data Types Legend

- `{DATEFORMAT}` - ISO 8601 date format. Dates shall be formatted as: `YYYY-MM-DD`.
- `{DECIMAL-n/m}` - Decimal number of up to `n` digits in total, of which up to `m` digits may be fractional. Numerical field supporting positive and negative values. Decimal separator: `.` (dot). Negative values are prefixed with `-` (minus). Values are rounded, not truncated.

Token Types Legend

- `OTHR` - Other Cryptoasset
- `ARTW` - Asset referenced token
- `EMTW` - E-money token

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

General information

S.1 - Name

The name of the person drawing up the whitepaper or the CASP publishing the disclosure.

In whitepapers, the name as reported inline with the Implementing Regulation:

- `A.1, Table 2` - Offeror or the person seeking admission to trading.
- `B.2, Table 1 / A.1, Table 4` - Issuer.
- `C.1, Table 3` - Operator of the trading platform.

In CASP website disclosures, the name of the CASP.

Format and reporting standard: `Free alphanumerical text`

S.2 - Relevant legal entity identifier

The legal entity identifier (LEI) of the person drawing up the whitepaper or the CASP publishing the disclosure.

National identifier as per the applicable national law, including cases where an LEI is not available.

LEIs are obtained from Global Legal Entity Identifier Foundation

Format and reporting standard: `Free alphanumerical text`

S.3 - Name of the crypto-asset

The crypto-asset project name.

In cases where the crypto-asset project is referred to by more than one name, the most widely used name is used across market sources including DTI database (long name) and crypto-asset market data aggregators.

Format and reporting standard: `Free alphanumerical text`

S.4 - Consensus Mechanism

A detailed explanation of the consensus mechanism, defined as ‘the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions’.

The information is collected and summarised from the documentation sources of the crypto-asset. Detailed names of consensus mechanisms alongside acronyms are provided.

Format and reporting standard: `Free alphanumerical text`

S.5 - Incentive Mechanisms and Applicable Fees

A detailed explanation on the incentive mechanisms to secure transactions and any fees applicable. This includes, but is not limited to:

- Transaction/gas fees.
- Block subsidy/rewards.
- Staking/delegation rewards.
- Transaction burn mechanisms.

Format and reporting standard: `Free alphanumerical text`

S.6 - Beginning of the period to which the disclosure relates

The start date of the reporting period of the disclosure.

Format and reporting standard: `{DATEFORMAT}`

S.7 - End of the period to which the disclosure relates

Disclosures are valid for 12-months from the starting date reported in `S.6`. For example, if `S.6` is `2024-01-01`, then `S.7` would be `2024-12-31`.

Format and reporting standard: `{DATEFORMAT}`

Mandatory key indicator on energy consumption

S.8 - Energy consumption

"Energy consumption" (of the consensus mechanism) is the total amount of energy used for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions, expressed in kWh per calendar year.

Energy Consumption being a mandatory indicator, is a core focus of the environment-related adverse impact disclosure for all crypto-assets. The energy consumption is scoped to that of the consensus mechanism. It leads to concepts like 'MiCA Scoped Nodes', or 'Scoped Nodes'. The focus is upon the energy used in the forming of consensus and maintaining the transaction ledger across DLT Nodes.

The sources and methodologies for this calculation `S.8` are detailed in Section 3 - Energy Consumption Sources and Methodologies (S.9) to support the `S.9` disclosure.

Format and reporting standard: `Amount in kilowatt-hours (kWh) {DECIMAL-18/5}`

Sources and methodologies

S.9 - Energy consumption sources and methodologies

The Energy consumption sources and methodologies to accompany disclosures in `S.8` are provided in Section 3 - Energy Consumption Sources and Methodologies (S.9).

Format and reporting standard: `Free alphanumerical text`

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

This information is required to be reported where the energy consumption of the crypto-asset exceeds 500,000 kWh. This follows the guidance in the Delegated Regulation Articles 4(2) and 5(2)(b).

Supplementary key indicators on energy and GHG emissions

S.10 - Renewable energy consumption

Share of energy used generated from renewable sources, expressed as a percentage of the total amount of energy used per calendar year, for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions.

Section 4 - Key energy sources and methodologies (S.15)

Format and reporting standard: `Percentage {DECIMAL-11/10}`

S.11 - Energy intensity

Average amount of energy used per validated transaction.

This is calculated from Energy consumption calculation `S.8` divided by the number of transactions during the disclosure period `S.6` - `S.7` (calendar year).

Section 4 - Key energy sources and methodologies (S.15)

Format and reporting standard: `Amount in kWh {DECIMAL-18/5}`

S.12 - Scope 1 DLT GHG emissions – Controlled

Scope 1 GHG emissions per calendar year for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions.

These are assumed to be zero.

A detailed explanation of the sources and methodologies for this section are provided in Section 5 - Key GHG sources and methodologies (S.16).

Format and reporting standard: `Amount in tonnes (t) carbon dioxide equivalent (CO2e) {DECIMAL-18/5}`

S.13 - Scope 2 DLT GHG emissions – Purchased

Scope 2 GHG emissions, expressed in tCO2e per calendar year for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions.

These are calculated using the energy consumption reported in S.8, alongside the geographical locations of nodes, and global energy mix data.

A detailed explanation of the sources and methodologies for this section are provided in Section 5 - Key GHG sources and methodologies (S.16).

Format and reporting standard: `Amount in tCO2e {DECIMAL-18/5}`

S.14 - GHG intensity

Average GHG emissions (scope 1 and scope 2) per validated transaction.

The sum of S.12 and S.13

Format and reporting standard: `Amount in kilogram (kg) CO2e (Tx) {DECIMAL-18/5}`

Sources and methodologies

S.15 - Key energy source and methodologies

The Energy consumption sources and methodologies to accompany disclosures in `S.10 - S.11` are provided in Section 4 - Key energy sources and methodologies (S.15).

Format and reporting standard: `Free alphanumerical text`

S.16 - Key GHG sources and methodologies

Sources and methodologies used in relation to the information reported in fields `S.12`, `S.13` and `S.14`.

A detailed explanation of the sources and methodologies for this section are provided in Section 5 - Key GHG sources and methodologies (S.16).

Format and reporting standard: `Free alphanumerical text`

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

Optional indicators

S.17 - Energy Mix

Description of the relative contributions of each different primary energy source used for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions, expressed as percentages.

Format and reporting standard: `Percentage {DECIMAL-11/10}`

S.18 - Energy use reduction

Energy use reduction targets or commitments, expressed in absolute or relative reduction of energy use over one calendar year.

Energy use reduction targets are rarely available in the source content of cryptoasset, at the time of writing. As the sustainability topic evolves, the information may be more readily available in the documentation.

Format and reporting standard: `Amount in kWh {DECIMAL-18/5} or Percentage {DECIMAL-11/10}`

S.19 - Carbon intensity

Carbon intensity of the energy used for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions.

Format and reporting standard: `Amount in kgCO2e per kWh {DECIMAL-18/5}`

S.20 - Scope 3 DLT GHG emissions - Value chain

Scope 3 GHG emissions for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions per calendar year.

'scope 3 DLT GHG emissions' means all indirect GHG emissions that are not covered by points (f) and (g) that occur in the value chain of the DLT network nodes applying the consensus mechanism, including both upstream and downstream emissions, Article 1(e) Delegated Regulation.

Format and reporting standard: `Amount in tCO2e {DECIMAL-18/5}`

S.21 - GHG emissions reduction targets or commitments

GHG emissions reduction targets or commitments, expressed in terms of absolute or relative reduction in GHG emissions over one calendar year.

Format and reporting standard: `Free alphanumerical text`

S.22 - Generation of waste electrical and electronic equipment WEEE

Total amount of WEEE generated for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions per calendar year.

Format and reporting standard: `Amount in t {DECIMAL-18/5}`

S.23 - Non-recycled WEEE ratio

Share of the total amount of WEEE generated for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions, not recycled per calendar year.

Format and reporting standard: `Percentage {DECIMAL-11/10}`

S.24 - Generation of hazardous waste

Total amount of hazardous waste generated for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions per calendar year.

Format and reporting standard: `Amount in t {DECIMAL-18/5}`

S.25 Generation of waste (all types)

Total amount of waste generated by the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions.

Format and reporting standard: `Amount in t {DECIMAL-18/5}`

S.26 - Non-recycled waste ratio (all types)

Share of the total amount of waste generated for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions not recycled per calendar year.

Format and reporting standard: `Percentage {DECIMAL-11/10}`

S.27 - Waste intensity (all types)

Total amount of waste generated per transaction validated.

Format and reporting standard: `Amount in grams (g) per Tx {DECIMAL-18/5}`

S.28 - Waste reduction targets or commitments (all types)

Waste reduction targets or commitments, expressed in absolute or relative reduction in waste generation over one calendar year.

Format and reporting standard: `Free alphanumerical text`

S.29 - Impact of the use of equipment on natural resources

Description of the impact on natural resources of the production, the use and the disposal of the devices of the DLT network nodes.

Format and reporting standard: `Free alphanumerical text`

S.30 - Natural resources use reduction targets or commitments

Natural resources use reduction targets or commitments, expressed in absolute or relative reduction in use of natural resources over one calendar year.

Format and reporting standard: `Free alphanumerical text`

S.31 - Water use

Total water consumption linked to the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions, expressed in cubic meters.

Format and reporting standard: `Amount in cubic meters {DECIMAL-18/5}`

S.32 - Non-recycled water ratio

Share of the total water consumed not recycled and not reused linked to the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions per calendar year, expressed as a percentage.

Format and reporting standard: `Percentage {DECIMAL-11/10}`

Sources and methodologies

S.33 - Other energy sources and methodologies

Sources and methodologies used in relation to the information reported in fields `S.17-S.18`.

Format and reporting standard: `Free alphanumerical text`

S.34 - Other GHG sources and methodologies

Sources and methodologies used in relation to the information reported in fields `S.19-S.21`.

Format and reporting standard: `Free alphanumerical text`

S.35 - Waste sources and methodologies

Sources and methodologies used in relation to the information reported in fields `S.22-S.28`.

Format and reporting standard: `Free alphanumerical text`

S.36 - Natural resources sources and methodologies

Sources and methodologies used in relation to the information reported in fields `S.29-S.32`.

Format and reporting standard: `Free alphanumerical text`

Section 3 - Energy Consumption Sources and Methodologies (S.9)

This section supports the disclosure in S.9 and outlines the sources and methodologies used to calculate the energy consumption reported in field S.8

Methodological Scope

The following ‘Supporting Definitions’ create a methodological scope for calculations of energy consumption focused around:

- Consensus mechanisms.
- Storing of complete or partial replica of records of all transactions.
- Synchronising state between a set of DLT network nodes.

Supporting Definitions

distributed ledger
: Keeps a record of transactions that is shared and synchronised between a set of DLT network nodes using a consensus mechanism, MiCA Article 3 (1)(1).

DLT network node
: Means a device or process that is part of a network and that holds a complete or partial replica of records of all transactions on a distributed ledger, MiCA Article 3(1)(4).

consensus mechanism
: The rules and procedures by which an agreement is reached, among DLT network nodes, that a transaction is validated, MiCA Article 3(1)(3).

energy consumption
: The total amount of energy used for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions, expressed per calendar year, ESMA Final Report.

Regulatory Guidance for Model

ESMA Final report 2.2(2.2.1)(4) notes that the sustainability impact of consensus mechanisms can be anchored in three main features of the DLT network nodes:

- The hardware devices that each DLT network node uses to take part in the DLT network and to hold a replica of all records on a distributed ledger.
- The energy consumption of each DLT network node.
- Their location.

Model Steps

Step 1 - Cryptoasset classification

The first step in the methodology is to determine whether the subject crypto-asset is a network or a token. This classification dictates how energy consumption is assessed for disclosure purposes.

- Networks are distributed ledgers that operate their own consensus mechanisms.

- Tokens are issued or deployed on top of these networks and inherit the environmental characteristics of the underlying infrastructure.

The energy consumption is first calculated for Networks, before being attributed to the tokens as per Step 7 - Energy Consumption Attribution.

Step 2 - DLT Network Review

A review of the DLT Networks documentation is undertaken to understand:

- The consensus mechanism.
- The nodes responsible for consensus.
- Dependencies the consensus nodes for operation.
- Availability of data.

Step 3 - Node Hardware Specifications

Distributed ledger networks consist of nodes that execute software clients on physical or virtual hardware. These clients perform roles critical to maintaining the integrity of the ledger, ranging from transaction validation to state propagation and data access. Hardware specifications for these clients are sourced from publicly available documentation issued by client developers.

Example Hardware Specification:

Field	Value
Client Name	Example Name
Client Type	Consensus
Architecture	64 bit
Number of Cores	4
GB RAM	16
GB Storage	2,000
Client Specification Source	www. example URL .com

Methodology and Assumptions

- The unit of analysis is the consensus-participating node - i.e. a node that contributes to transaction validation and ledger finality as scoped under the MiCA sustainability disclosures.
- Each DLT network includes one or more client implementations that enable participation in the consensus process and, in some cases, additional infrastructure layers.
- For networks with separate client roles (e.g. execution vs. consensus responsibilities), the methodology evaluates the combined client stack typically run by a participating node.
- Where multiple client implementations exist, the linear distribution of clients across the network (sourced from public crawlers or telemetry data) is used to model the client mix.
- Recommended hardware specifications are extracted from official client documentation. Where multiple profiles are published (e.g. “minimum” vs. “recommended”), the mid-point or recommended spec is selected to reflect realistic node deployment practices.
- Where required specifications are missing for a client, median values from peer clients or similar implementations are used to fill gaps conservatively.
- In cases where multiple versions of a client are in use, the most recent version’s specifications are applied for modelling consistency.
- Only clients with an observed network share of ≥1% are included in the model. This threshold avoids overfitting to deprecated, experimental, or unstable configurations, and mitigates volatility from low-frequency client identification. The distribution of included clients is normalised to reflect the total consensus-participating node population at the point in time.

Drawbacks and Considerations

- **Documentation Reliability**: Published hardware recommendations may be out of date, incomplete, or strategically optimistic to reduce perceived barriers to node operation.
- **Client Diversity**: Some client distributions may still be operating in legacy or semi-deprecated states not reflected in official documentation.
- **Crawling Limitations**: Client share data may be incomplete or noisy, especially for networks with partial visibility into peer topology or use of anonymising overlays.
- **Storage Growth and Lag in Updates**: Blockchain node storage requirements increase over time as the ledger expands. This methodology relies on point-in-time snapshot values. While this avoids speculative forecasting, it may underrepresent actual storage consumption in periods of rapid growth, introducing a lag between real-world conditions and model updates.
- **Scope of Inclusion**: Clients with less than 1% observed share are excluded from modelling due to their instability, short-lived nature, or limited documentation. While this approach avoids introducing noise and reduces the need for frequent model refreshes, it assumes that these fringe configurations do not materially affect aggregate energy consumption estimates.

Step 4 - Server Energy Specifications

Once node-level hardware requirements are established, these specifications are mapped to commercially available server types - typically virtual machine (VM) configurations from major cloud service providers. These mappings serve as proxies for estimating the energy consumption of node operation in realistic deployment scenarios.

By grounding estimates in actual infrastructure offerings, this approach enhances transparency, consistency, and reproducibility in ESG reporting across diverse DLT networks. It reflects the observation that a majority of nodes (>50%) are deployed on cloud-hosted infrastructure.

Methodology and Assumptions

- **Cloud Dominance**: The majority of nodes across DLT networks are deployed via public cloud infrastructure. Modelling server energy profiles using standard VM types ensures alignment with real-world node hosting practices.
- **Hardware-to-VM Mapping**: CPU, memory, and storage requirements drawn from client documentation, are matched to the lowest-cost compatible VM instance available from major cloud providers. This reflects the assumption that economically rational node operators aim to minimise costs while maintaining functional performance.
- **Empirical Power Data**: Power draw estimates are informed by energy benchmarking studies and published datasets for representative server hardware. These sources offer power consumption profiles across idle, average, and high-load conditions, based on measured performance under diverse operational scenarios - not limited to synthetic stress tests. This grounding ensures that energy use assumptions reflect realistic infrastructure behaviour over time.
- **Utilisation Rate:** A standard 50% server utilisation rate is applied, representing a balanced estimate of average resource use across the lifecycle of a distributed ledger node. This assumption captures both active processing (e.g. transaction validation) and idle states (e.g. data storage, ledger maintenance), aligning with regulatory definitions that require disclosure of total annual energy use for the operation and integrity of a DLT network. It reflects real-world infrastructure provisioning strategies, which are built to accommodate surge capacity without assuming constant peak performance. This approach avoids overfitting to transient network conditions or highly specific node setups. Given the substantial diversity in client types, hardware configurations, and deployment preferences (node configuration), applying a consistent average utilisation rate supports methodological stability, reduces sensitivity to user-driven variation, and enhances comparability of energy estimates across blockchain ecosystems.
- **Full Scope Inclusion**: Energy modelling encompasses compute, networking, and storage functions, as well as system overhead from operating systems and auxiliary services.
- **Fallback Estimation**: Where direct benchmarks are unavailable, power usage is inferred from hardware specifications (e.g. CPU TDP, RAM size) using representative server configurations.

- **Storage Conversion**: Storage requirements (e.g. in GB or TB) are converted into power draw using industry-standard conversion factors derived from storage power density data for SSD.
- **Cost-Minimising Rationality**: Node operators are assumed to act economically, selecting the most affordable VM instance that satisfies the technical requirements for stable operation.

Drawbacks and Considerations

- **Opaque Virtualisation Layers**: Public cloud providers do not disclose the underlying physical infrastructure powering virtual machines. As a result, modelling must rely on assumptions about how virtual workloads map onto actual hardware energy usage, which may vary across instance families and deployment regions.
- **Heuristic Dependencies**: Energy estimates depend on empirical benchmarks, conversion factors, and hardware specifications - each a proxy rather than a direct measurement. When layered together, these heuristics can introduce compounding uncertainty.
- **Static Utilisation**: The application of a fixed 50% utilisation rate simplifies modelling and comparison but may overlook dynamic behaviour such as transaction spikes, validator churn, or network-specific performance characteristics.
- **Model Abstraction Trade-offs**: Normalising across VM types and applying a common utilisation baseline enhances consistency but also obscures operational nuances - including client-level optimisations, hybrid deployments, and differences in over- or under-provisioning.
- **Hardware Age and Degradation**: Over time, equipment may consume more power due to wear, thermal throttling, or reduced efficiency. These real-world ageing effects are not captured in the model's steady-state assumptions.
- **Shared Hosting Caveats**: In virtualised environments, multiple workloads may share a single physical host. This can lead to indirect or background energy usage ("noisy neighbour" effects) that cannot be directly attributed to node operation. The model mitigates this by consistently selecting the smallest viable server class for each configuration.

Step 5 - Client Telemetry

To accurately model node-level energy consumption, we incorporate client telemetry data obtained through network crawlers. These tools provide insight into the real-world distribution and behaviour of node software deployed across the network.

Methodology and Assumptions

Crawler-derived telemetry provides key observable characteristics of nodes, including:

- **Client Type and Version**: Identification of execution and consensus clients running across the network.
- **Geographic Location**: Country or region inferred from IP address, supporting location-based energy efficiency modelling.
- **Sync Status**: Whether the node is currently synchronised with the network, reflecting active vs. dormant operational status.
- **Operating System and Network Type**: Data extracted from open network ports and headers, where available.

Client behaviour is modelled with the following operational insights:

- **Standalone Execution/Consensus Clients**: Some nodes operate in partial roles (e.g., Beacon-only or RPC-only), and may not participate in consensus despite maintaining a presence in crawler data.
- **Sync Variability**: Nodes enter and exit sync states over time. Nodes out of sync are excluded from "scoped" consensus node counts but are retained in model logic as supporting infrastructure (e.g., warm failover, load balancing).
- **Client Process ≠ Physical Machine**: The telemetry represents processes, not unique hardware instances. A single physical server may host several client roles.

- **Cloud-Centric Modelling**: The model emphasises cloud-hosted nodes due to their higher reliability, consistency, and materiality in energy footprint. Non-cloud deployments (e.g., residential or mobile nodes) are currently out of scope but may be included in future iterations.
- **Geolocation Precision**: IP-based geolocation may be distorted by VPNs, tunnels, or routing obfuscation. Where location cannot be resolved confidently, such nodes are excluded from regional allocation, and known percentages are renormalised.
- **Client Distribution Assumption**: Where client roles are segmented (e.g. consensus vs. execution), the model assumes that node deployments span all valid client combinations. In the absence of joint deployment data, an independent distribution is assumed - each client pair's share is computed as the product of individual client shares. If needed, this distribution is normalised to ensure proportional weighting across the node population. Execution clients are assumed to be evenly distributed across consensus clients unless verifiable pairing data is available.

Drawbacks and Considerations

- **Crawler Limitations**: Crawlers depend on network visibility. Nodes behind firewalls, NATs, or private deployments may evade detection.
- **Data Freshness**: Crawling captures a moment-in-time snapshot. Rapid changes in network state, client usage, or validator migration may not be reflected in near real time.
- **Interpretation Complexity**: Distinguishing between physical machines, virtual nodes, and client processes is difficult without intrusive instrumentation.
- **Geolocation Uncertainty**: IP-based location can be inaccurate, especially where privacy tools or regional redirection are in use.
- **Node Duplication and Multiplexing**: Nodes may be running higher hardware specifications leading to an underestimate of energy consumption, since optimised node setups may run multiple client processes:
    - One execution client can serve many consensus clients.
    - One consensus client may operate thousands of validator keys simultaneously.
- **Validator Density**: Large-scale operators frequently concentrate validators on high-performance infrastructure, dramatically increasing validator count per machine (common in proof-of-stake networks).

Step 6 - Global Energy Efficiency Statistics

To reflect real-world infrastructure energy overheads, the model incorporates Power Usage Effectiveness (PUE) data - representing the ratio of total energy used by data centres to the energy delivered specifically to computing equipment. This enables location-adjusted estimations of actual electricity demand per node, accounting for cooling, redundancy, and other facility-level factors.

Methodology and Assumptions

- **Power Usage Effectiveness (PUE) multiplier:** We incorporate PUE into our energy consumption estimates to reflect the real-world overheads associated with hosting infrastructure, such as cooling, power conversion, and facility operations. This inclusion is warranted given the widespread reliance on cloud-hosted and commercial data centre deployments across DLT networks, where such overheads are material and measurable. Unlike methodologies that assume self-hosted or consumer-grade hardware without auxiliary infrastructure, our model reflects modern hosting realities in which PUE significantly affects total electricity demand.
- **PUE Integration**: Regional PUE values are used as multipliers in the final energy consumption equation.
- **Geographic Weighting**: Node location (as inferred via client telemetry) determines which regional PUE value is applied.
- **Fallback Hierarchy**:
    - If country-level PUE data is available, it is used.
    - If unavailable, regional PUE is used (based on ISO and hyperscaler region logic).

    - If still unavailable, a global average is applied as a last resort.
- **Regional Groupings**: PUE regions are based on cloud service provider segmentation and grid infrastructure, not strictly geography. They reflect where the node most likely operates in terms of energy characteristics:

PUE Region	Notes
Global	Default fallback where location is unknown or unclassifiable
Europe	Includes EU and microstates (e.g. Jersey, Isle of Man, Andorra)
North America	Includes USA, Canada, and extended to Central America and the Caribbean
Central/South America	Latin American countries not grouped with North America
Middle East	Includes UAE, Türkiye, Israel, Iran (even if geographically Asian)
Africa	All African countries
Asia Pacific (excl. CN)	Includes Australia, New Zealand, HK, Taiwan, Macao, Central Asia
China	Separated due to distinct infrastructure, energy profile, and regulation
...	...

Update Cadence: Global energy efficiency statistics are not updated frequently. The model incorporates the most recent credible dataset and is refreshed when significant new PUE benchmarks are published.

Drawbacks and Considerations

- **Data Lag**: PUE data often lags real-time infrastructure changes and may not reflect recent upgrades or efficiencies in hyperscaler operations.
- **Regional Averaging**: Broad groupings (e.g. Asia Pacific) may mask significant country-level variation in data centre performance or grid efficiency.
- **Data Source Transparency**: PUE values are typically self-reported by infrastructure providers and may be subject to marketing or compliance biases.
- **Exclusion of Non-Cloud Setups**: Residential or enterprise-hosted nodes may operate in vastly different environments, with higher or lower PUE values. These effects are not modelled at present.
- **No Lifecycle Scope**: PUE captures operational efficiency, not embodied emissions from equipment manufacture, lifecycle, or end-of-life considerations.

Step 7 - Energy Consumption Attribution

When calculating `S.8 Energy consumption`, the classification from Step 1 guides the methodological path.

Methodology and Assumptions

A. Networks

For crypto-assets identified as networks, energy consumption is calculated using the full methodological framework outlined in this document. This includes node-level estimates, consensus mechanism characteristics, and cloud-mapped infrastructure assumptions.

Many networks have native tokens or wrapped versions on other chains. Token classification is based on the Digital Token Identifier (DTI) system, where tokens are grouped into Functionally Fungible Groups by the Digital Token Identifier Foundation and cryptoasset market data providers.

B. Tokens

For crypto-assets identified as tokens, energy consumption is derived from the underlying network on which the token is deployed.

- Tokens inherit the energy and emissions characteristics of their host DLT network.
- Only the direct energy consumption associated with the consensus mechanism of the base network is considered.
- Broader indirect impacts (e.g. off-chain dependencies) are excluded from the scope.

Token Energy Consumption Attribution Assumptions

To allocate `S.8 Energy consumption` at the token level, we estimate a token's share of the network's total energy use by calculating the token's proportion of network transactions.

This approach reflects two core regulatory expectations under the Delegated Regulation:

1. **Comparability across crypto-assets –** Article 3(1)(b) requires that disclosures "facilitate comparisons" across the assets for which services are provided. Transaction-based attribution supports a consistent and scalable method for cross-asset assessment.
2. **Focus on consensus-related activity –** Disclosures are scoped to energy used for validating transactions and maintaining the integrity of the ledger. A token's transaction share offers a practical proxy for its use of consensus-related infrastructure.

Use of Transaction Count as Attribution Basis

We adopt a transaction-count allocation model for the following reasons:

- **Practicality and comparability**: Transaction counts are widely available across networks and more consistent than alternative metrics (e.g. gas, value).
- **User-aligned**: The method reflects real-world usage patterns, enabling intuitive interpretation.
- **Scope-aligned:** the model scope is focused on energy consumption for validating transactions. Transaction count and share is a reliable way to attribute and align to the scope as part of a multi DLT network model.
- **Marginal impact**: It assumes that each transaction imposes a roughly equal marginal load on the network over time - reasonable in aggregate, even if imperfect on a per-transaction basis.

  Note: We define a transaction as a unique transaction hash. Internal transactions or embedded operations are excluded unless explicitly identifiable across network data providers.

While scaling solutions (e.g. rollups) bundle many user actions into single transactions with higher gas use, our model maintains clarity by counting each finalised on-chain transaction as one unit of load. This aligns with throughput metrics such as transactions per second (TPS), which are commonly used as top-level indicators of network activity.

Server Utilisation Assumption Harmony with Transaction Count

The model assumes a 50% server utilisation rate, reflecting typical cloud provisioning scenarios. This assumption:

- Encapsulates idle energy costs for maintaining network and ledger state.
- Avoids overfitting to peak or idealised performance metrics.
- Ensures consistent estimation across different DLTs and deployment patterns.

By combining this baseline with transaction-based attribution, the model captures both:

- **Baseline (idle) energy –** abstracted via the 50% utilisation assumption.
- **Incremental (usage-driven) energy –** proportionally assigned via transaction share.

  In effect, tokens that generate more on-chain activity are attributed a larger share of both active and passive energy usage across the network's consensus and state-maintenance infrastructure.

Why Not Use Gas Fees?

Gas fees were evaluated as a potential allocation method but ultimately not adopted for the following reasons:

- **Inconsistent across networks**: Bitcoin fee rates determine the ordering of transactions within block template construction. However, all valid transactions - regardless of fee - enter the mempool and are relayed across the network. During periods of low demand, low-fee transactions are eventually confirmed without altering the block production schedule. As such, low fees do not translate to lower energy consumption, and transaction inclusion is decoupled from marginal environmental impact.
- **Gas ≠ energy:** Gas measures the computational complexity of operations, not the actual electricity consumed. A high-gas transaction does not necessarily equate to proportionally higher energy use, especially given hardware, batching, and node-level optimisation.
- **Behaviour-driven variability**: Gas prices fluctuate with network congestion and user incentives, not underlying hardware resource usage.

Why Not Use Monetary Value?

Allocating emissions based on market cap or investment size (i.e. "ownership-based attribution") was also considered. However:

- It reflects investment exposure, not infrastructure usage.
- It's detached from actual network activity and would fail to satisfy MiCA's emphasis on operational impact tied to consensus mechanisms.

Drawbacks and Considerations

While pragmatic and consistent, a transaction-count methodology carries known limitations:

- **Transaction heterogeneity**: Not all transactions consume equal resources. Some involve basic value transfers, while others may trigger complex smart contract executions. Treating them equally flattens real differences in computational load.
- **Gas variance and complexity**: On Ethereum, for example, block size is defined by a maximum gas limit rather than a strict data size. This means a single block could include fewer, high-gas (and potentially high-complexity) transactions or many simpler ones - without affecting total block production or energy cost in a linear way.
- **Bitcoin contrast**: In contrast, Bitcoin defines block limits by maximum data size (e.g. 4 MB with SegWit). Yet, the energy consumption per block remains constant due to Proof-of-Work dynamics, making per-transaction attribution more abstract.
- **Energy doesn't scale linearly with transaction count**: Most node energy use is steady-state (e.g. syncing, maintaining chain state, peer communication), and only marginally affected by transaction volume within capacity bounds. This means our method captures relative usage share, but not exact marginal electricity draw.
- **Failed transactions use energy:** Gas spent covers all transactions, even failed. Our model attributes only successful transactions. Higher gas means higher likelihood of inclusion in a block. Our assumption of a 50% utilisation rate abstracts this. We assume that there is a linear distribution of failed transactions across all cryptoassets. With Bitcoin, low fee rates are processed eventually (unless the mempool is purged). Those transactions are still being relayed, for longer. Lower gas in that context is misleading, since actually low fee rates spend considerably longer in the mempool waiting to be relayed. Thus, leading back to our original favouring of comparability between blockchains to make disclosures fair, clear and not misleading. It also raises theoretical questions such as: were the very first runes that launched less sustainable than runes deployed today because higher gas was used? The Proof of Work moves gradually, largely unchanged day-to-day. No additional environmental impact was felt from the higher runes mint.

These limitations are acknowledged as part of the trade-off for model reproducibility and cross-network consistency. The transaction-based method is aligned with disclosure objectives under MiCA and provides a credible, neutral basis for estimation and comparison - particularly in the absence of fine-grained gas or compute-level telemetry per token.

Energy Consumption Calculation and Equations

Core Network Equation

$$E_{\text{total}} = \sum_{i=1}^{N_{\text{nodes}}} P_{\text{node},i} \times \text{PUE}_i \times H$$

E_{total} : Total annual energy consumption of all scoped nodes (in kilowatt-hours, kWh)
$P_{\text{node},i}$: Power draw of node i (in kilowatts, kW)
PUE_i : Power Usage Effectiveness multiplier for node i (dimensionless)
H : Number of hours in a year (8760)
i : Index over all scoped nodes ($i = 1, 2, \dots, N_{\text{nodes}}$)

Number of Nodes Equation

$$N_{\text{nodes}} = N_{\text{synced}} + N_{\text{syncing}}$$

N_{nodes} : Total number of scoped nodes (used in energy attribution)
N_{synced} : Number of nodes currently in sync with the network
N_{syncing} : Number of nodes actively syncing with the ledger

Power of Node Equation

$$P_{\text{node},i} = P_{\text{server}}(o_i, h_i) + f(s_i)$$

$P_{\text{node},i}$: Power draw of node i (in kilowatts, kW)
$P_{\text{server}}(o_i, h_i)$: Server power (kW) under 50% utilisation, as per OS and hardware profile
o_i : Operating system of node i (e.g., Linux or Windows)
h_i : Hardware profile of node i (e.g., CPU cores, RAM)
s_i : Storage requirement of node i (in GB)
$f(s_i)$: Storage power draw function, e.g., $f(s) = \frac{s}{1000} \times \kappa$ W

PUE of Node Equation

$$\text{PUE}_i = \text{PUE}_{\text{region}(g_i)}$$

g_i : Geographic location of node i (e.g., inferred from IP)
$\text{PUE}_{\text{region}(g_i)}$: Regional average Power Usage Effectiveness value for location g_i

Client Splits Equation

$$P(c_i, e_j) = P(c_i) \times P(e_j)$$

$P(c_i)$: Observed proportion of the network using consensus client c_i
$P(e_j)$: Observed proportion of the network using execution client e_j
$P(c_i, e_j)$: Assumed joint proportion of the network using client pair (c_i, e_j)

Token Energy Attribution Equation

$$E_{t_k} = \sum_{n=1}^{N} \left(\frac{T_{t_k,n}}{T_n} \times E_n \right)$$

E_{t_k} : Total annual energy consumption attributed to token t_k (in kWh)
n : Index over all networks $(n = 1, 2, \ldots, N)$
$T_{t_k,n}$: Number of transactions involving token t_k on network n
T_n : Total number of transactions on network n
E_n : Total annual energy consumption of network n (in kWh)

Section 4 - Key energy sources and methodologies (S.15)

This section supports the disclosure in S.15 and outlines the key energy sources and methodologies used to calculate the ... reported in fields S.10 - S.11

S.10 - Renewable energy consumption

Supporting Definitions

energy from renewable sources (renewable energy)
Energy from renewable non-fossil sources, namely wind, solar (solar thermal and solar photovoltaic) and geothermal energy, ambient energy, tide, wave and other ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas, and biogas, Article 2(1) Directive (EU) 2018/2001.

Methodology and Assumptions

In line with the EU's definition, the following sources are considered renewable energy:

- Wind
- Solar (solar thermal and solar photovoltaic)
- Geothermal energy
- Ambient energy
- Tide, wave and other ocean energy
- Hydropower
- Biomass
- Landfill gas, sewage treatment plant gas, and biogas

Node geolocation data, derived from IP addresses as collected through Client Telemetry, is mapped to country-level renewable energy shares. An illustrative distribution of nodes by geography is shown below:

Country	Percentage	Country Code	Flag	Region
United States	31.041	US	🇺🇸	North America
Germany	12.086	DE	🇩🇪	Europe
Finland	3.149	FI	🇫🇮	Europe
France	3.389	FR	🇫🇷	Europe
United Kingdom	4.459	GB	🇬🇧	Europe
...	...	...	...	...

Note: Values rounded to 3 decimal places.

To assess renewable energy consumption, we reference the Energy Institute Statistical Review of World Energy 2024, which categorises energy consumption by fuel type:

- Oil
- Natural Gas
- Coal
- Nuclear energy
- Hydro electric
- Renewables

These national energy mixes (for the year 2023) are converted to percentages per country. Below is an excerpt from the conversion:

	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renewables
Canada	0.312	0.312	0.027	0.057	0.244	0.048
Mexico	0.454	0.416	0.031	0.013	0.023	0.064
US	0.380	0.338	0.087	0.078	0.023	0.093
...	...	...	...	...	...	...

Where IP addresses are not available for node crawling, we approximate using global averages.

Where geolocation is unavailable for a node, a fallback global average renewable share is applied.

> **Source:** Energy Institute Statistical Review of World Energy 2024.

Drawbacks and Considerations

- **Geolocation Limitations**: IP-based geolocation may be imprecise due to VPNs, tunneling, or NAT environments. Where node location is unknown, a fallback global average renewable share is applied.
- **Data Recency**: National energy mix data is drawn from the prior calendar year and may not reflect recent shifts in energy policy or infrastructure.
- **Regional Averaging**: Country-level data may obscure sub-national or regional variation in renewable intensity.
- **Assumption of National Grid Parity**: It is assumed that nodes draw electricity in line with their country's average grid mix. Green-hosted, off-grid, or bespoke infrastructure is not separately modelled.
- **Static Node Distribution**: Node distribution is treated as a snapshot in time. Rapid changes in decentralisation, migration, or network topology may not be reflected.
- **Representativeness**: Each node is assumed to consume energy in proportion to the national average for its location, without weighting for node type or activity level.

Renewable Energy Consumption Calculation

$$RE_{\%} = \sum_{j=1}^{N_{\text{countries}}} P_j \times R_j$$

$RE_{\%}$: Estimated share of renewable energy as a percentage of total energy use
P_j : Proportion of nodes located in country j
R_j : Share of electricity from renewable sources in country j
$N_{\text{countries}}$: Total number of countries represented in the node distribution

S.11 - Energy intensity

The energy intensity metric is calculated by dividing the cryptoasset's total annual energy consumption (`S.8`, in kWh) by the number of transactions recorded over the same reporting period.

A detailed explanation of how energy consumption (`S.8`) is determined is provided in Section 3 – Energy Consumption Sources and Methodologies (`S.9`).

The relevant reporting period is defined in `S.6` (start date) and `S.7` (end date).

Section 5 - Key GHG sources and methodologies (S. 16)

This section supports the disclosure in `S.16` and outlines the sources and methods used to report Scope 1 and Scope 2 emissions, as well as the related GHG intensity metric in `S.12` - `S.14`.

S.12 - Scope 1 DLT GHG emissions - Controlled

Supporting Definitions

scope 1 DLT GHG emissions
GHG emissions generated from sources that are controlled by the DLT network nodes applying the consensus mechanism, Article 1(d) Delegated Regulation.

Methodology and Assumptions

This metric is assumed to be zero, under the following rationale:

Scope 1 emissions are direct emissions from sources owned or controlled by the DLT node operator. Examples include:

- Diesel generator emissions from on-site backup power systems
- On-site fossil fuel combustion (e.g. natural gas heating)

However, the majority of public DLT infrastructure is hosted in commercial data centres operated by third parties. In such cases:

- Node operators do not control physical infrastructure capable of producing direct emissions
- Virtual machines (VMs) abstract node execution from the physical hardware layer
- Power supply is centrally managed by hosting providers, not individual node operators

As a result, emissions directly attributable to the DLT operator's control are considered negligible or nonexistent.

Drawbacks and Considerations

- **Assumption of Full Virtualisation**: While the majority of nodes are cloud-hosted, edge cases (e.g. industrial-scale miners or institutional validators) may operate owned infrastructure with on-site emissions.
- **Unreported On-Premises Nodes**: Private or enterprise networks may operate validator infrastructure on-premises. If such setups exist within the scope of the disclosure, they could give rise to Scope 1 emissions not captured by this assumption.
- **Backup Generators and Off-Grid Nodes**: Edge deployments using backup diesel or off-grid energy sources could technically fall under Scope 1 but are not modelled explicitly due to lack of observable data.
- **Model Conservatism**: This zero-assumption approach prioritises comparability and simplicity but may understate emissions in rare cases where node operators self-host and consume fossil energy directly.

S.13 - Scope 2 DLT GHG emissions - Purchased

Supporting Definitions

scope 2 DLT GHG emissions

GHG emissions from the consumption of purchased electricity, steam, or other sources of energy generated upstream from the DLT network nodes applying the consensus mechanism, Article 1(e) Delegated Regulation.

Methodology and Assumptions

Scope 2 emissions represent the indirect greenhouse gas emissions associated with electricity purchased and used by the DLT node infrastructure. This section estimates those emissions by combining:

- the cryptoasset's total annual electricity consumption (from S.8),
- the geographic distribution of nodes,
- and national-level emissions intensities derived from public datasets.

The model estimates Scope 2 GHG emissions by applying a country-specific emissions factor - derived as total national emissions divided by total primary energy use - to the cryptoasset's total electricity demand, weighted by the geographic distribution of nodes.

Step 1 - Country-Level GHG Emissions

We begin with reported total national GHG emissions (Scope 1+2 equivalents) from energy, process emissions, methane, and flaring, as published by the Energy Institute Statistical Review of World Energy 2024.

Carbon Dioxide Equivalent Emissions: from Energy, Process Emissions, Methane, and Flaring

The table below shows Million tonnes of carbon dioxide equivalent per country:

Country	2023 Emissions ($MtCO_2e$)
Canada	599.370
Mexico	559.740
US	5130.148
...	...

Step 2 - Country Energy Consumption

Each country's primary energy consumption (in Exajoules, EJ) is also drawn from the same source. This metric reflects the energy input from fossil fuels and modern renewables.

Country	2023 Energy Use (EJ)
Canada	13.950
Mexico	8.453
US	94.281
...	...

Step 3 - Node Geolocation

The proportion of DLT nodes located in each country is determined using IP-based location data obtained through Client Telemetry. This distribution is used to weight country-specific emissions factors.

Country	Percentage	Country Code	Flag	Region
United States	31.041	US	🇺🇸	North America
Germany	12.086	DE	🇩🇪	Europe
Finland	3.149	FI	🇫🇮	Europe
France	3.389	FR	🇫🇷	Europe
United Kingdom	4.459	GB	🇬🇧	Europe
...	...	...	...	...

Step 4 - Energy Consumption of Cryptoasset

The total annual electricity consumption of the cryptoasset under assessment (in kilowatt-hours, kWh) is drawn directly from the `S.8` disclosure.

Drawbacks and Considerations

- **Input Equivalence vs. Final Energy:** The model derives national emissions intensities by dividing each country's total reported GHG emissions (from energy and process sources) by its total primary energy use. This provides a proxy for average emissions per unit of energy input, but it does not reflect electricity-specific emissions factors or final energy delivery. As such, it may not capture the effects of electricity grid composition, generation efficiency, or transmission losses.
- **Geolocation Accuracy**: IP-based location detection may misidentify hosting location, especially in virtualised infrastructure environments. Unknown nodes default to a global average intensity.
- **Grid-Average Assumption**: The methodology assumes that electricity consumed reflects the national average emissions intensity. This excludes effects of green procurement, RECs, or off-grid clean power setups.
- **Time Lag**: The data used refers to the previous calendar year and may not capture the most recent national energy transitions.

Scope 2 DLT GHG emissions – Purchased - Calculation

$$\mathrm{GHG}^{(2)}_{\mathrm{total}} = \sum_{g \in G} \left(P_g \times E_{\mathrm{total}} \times \frac{C_g}{PE_g} \right)$$

$$\begin{aligned}
\mathrm{GHG}^{(2)}_{\mathrm{total}} &: \text{Total estimated Scope 2 GHG emissions (in tonnes CO}_2\text{e)} \\
P_g &: \text{Proportion of nodes located in country } g \text{ (as a decimal)} \\
E_{\mathrm{total}} &: \text{Total annual electricity consumption of the cryptoasset (in kWh)} \\
C_g &: \text{Country } g\text{'s annual CO}_2\text{e emissions from energy (in million tonnes)} \\
PE_g &: \text{Country } g\text{'s annual primary energy consumption (in exajoules)} \\
g &: \text{Country index, as mapped from IP geolocation}
\end{aligned}$$

S.14 - GHG intensity

The GHG intensity metric represents the average greenhouse gas emissions (Scope 1 and Scope 2) per validated transaction.

It is calculated by summing the cryptoasset's total emissions reported in S.12 and S.13, and dividing this total by the number of transactions recorded over the same reporting period.

The relevant reporting period is defined in `S.6` (start date) and `S.7` (end date).