Methodology to calculate the mandatory sustainability indicators required by the EU Markets in Crypto-Assets (MiCA) regulation

This document refers to Circle’s Stablecoins USDC and EURC issued by Circle France

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The sustainability indicators as well as the methodology description in this document are provided by our partner CCRI - Crypto Carbon Ratings Institute.

Contents

Introduction and general remarks

The Markets in Crypto-Assets Regulation (MiCA) enters into application on 30 June 2024 for issuers of EMTs. Crypto-asset issuers as well as service providers are required to disclose information on the principal adverse impacts on the climate and other environment-related adverse impacts of the consensus mechanism used to issue the respective crypto-asset. The European Securities and Markets Authority (ESMA), which has been mandated to develop draft regulatory standards related to sustainability disclosure, has proposed ten mandatory climate and other environment-related indicators in their 2nd consultation package which was released on 5th October 2023. The ten indicators cover the areas of energy, GHG emissions, waste production, and natural resources. This document provides the methodology on how to derive the ten mandatory MiCA sustainability indicators proposed by ESMA for Circle's USDC and EURC stablecoins.

USDC and EURC issued by Circle France are available on the following chains:

Network	USDC availability	EURC availability
Ethereum	✓	✓
Avalanche	✓	✓
Stellar	✓	✓
Solana	✓	✓
Polygon	✓	✗
Arbitrum	✓	✗
Optimism	✓	✗
Base	✓	(estimate provided, launch in July 2024)
Noble	✓	✗
Algorand	✓	✗
Polkadot	✓	✗

Table: Overview of blockchains supported by Circle France

These are the blockchains that Circle France will initially, i.e. in the first two months after receiving the EMI license approval and launching the activity, support. Circle France will likely add additional blockchain support in the future and update the relevant sections of the white paper, including the sustainability indicators, accordingly.

On the following pages, we will provide a description to determine the MiCA sustainability indicators for each type of network that we assess. There are three categories to assess:

- **Layer 1 networks**: Regular networks with (in all cases) a Proof of Stake (PoS) consensus mechanism.
- **Layer 2 networks**: Layer 2 networks that depend on a layer 1 network, in all cases, Ethereum.
- **Tokens**: USDC and EURC on the indicated networks.

We calculate MiCA sustainability indicators for each base chain as well as for each token combination (e.g., USDC x Ethereum). In addition, a set of the ten mandatory MiCA sustainability indicators that aggregates the combinations to provide one single value per indicator for USDC and EURC, respectively.

Proposed mandatory MiCA sustainability indicators

The following four sections a.-d. shed light on the ten mandatory sustainability indicators proposed by ESMA – clustered by the environmental domain they relate to.

a. Energy

The first three indicators are energy consumption-related. Indicator 1 captures the total energy used for the validation of transactions and the maintenance of the integrity of the distributed ledger. Indicator 2 quantifies the non-renewable share, and Indicator 3 the per-transaction energy usage. Further details are provided below for each of the indicators.

Indicator 1 – Energy consumption

"Total amount of energy used, expressed in kilowatt-hours (kWh) per calendar year, for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions"

- ESMA, Consultation Package 2, Annex II, Table 1

For the first indicator, ESMA defines the total energy consumption of the network that is required for the validation of transactions and the maintenance of the integrity of the distributed ledger. It makes the important distinction between transactions and maintenance of the ledger, such that in later metrics we can discern between the two. For a proper assessment of Indicator 1, one needs to also consider the impact of transactions on the overall electricity consumption in the network.

Proof of Stake:

For Proof of Stake (PoS) networks, a uniform approach can be applied to generate the total electricity consumption. The driver of the total electricity consumption in such networks is the node devices in the network, both their count as well as their individual power demand.

"Number of nodes" is a metric that is often readily available. Block explorers or other data providers are able to analyze the P2P network and understand how many entities are connected to the network and provide (depending on the specific algorithm) computational and storage capacity. It is important to discern between full nodes and validating nodes, as only the latter provide "validation of transactions and maintenance of the integrity to the distributed ledger". Therefore, we rely on validator numbers instead of total network nodes.

In contrast to the number of nodes, the power demand of the individual devices is not available. Some research papers estimate the power demand per node based on common hardware requirements of the network. However, such an approach does not allow for nuanced differentiations between different networks, as it is not possible to deviate average power demands from basic performance metrics of the network, such as transaction throughput. This can be addressed through generating the data by setting up nodes and measuring the electricity consumption in real-world scenarios. CCRI has developed a reference hardware set that includes low-tier nodes such as a Raspberry Pi up to server-grade hardware. With this hardware set, CCRI has generated data for an average node of each of these blockchain networks. The individual power demand is enhanced with a marginal electricity consumption per transaction that is calculated based on the power demand and transaction throughput of the node during a measurement period. A detailed description of the methodology applied by CCRI is available.[1]

Tokens

To calculate the total energy consumption of a token that exists on a blockchain, one needs to first understand the energy consumption of the underlying network (see previous section). Once this data is readily available, one can allocate the total energy consumption to an individual token. CCRI uses the well-established hybrid allocation framework[2] to properly calculate the electricity consumption of the token. A detailed description of this approach can be found in the description of Indicator 3.

Layer 2 networks

Layer 2 networks employ their own consensus mechanisms in addition to being responsible for the activity on the base chain that provides additional security guarantees. For estimating the electricity consumption of layer 2 networks, we combine the PoS approach (for the own network) with the token approach (for the base layer network) and add them up for total electricity consumption.

Indicator 2 – Non-renewable energy consumption

> "Share of energy used generated from non-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"
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

[1] https://carbon-ratings.com/dl/whitepaper-pos-methods-2023
[2] https://carbon-ratings.com/accounting-framework-2022

The calculation of the share of non-renewable energy consumption is not dependent on the type of blockchain or consensus mechanism but directly builds on the energy consumption (Indicator 1). Therefore, the same approach fits all different blockchain consensus mechanisms.

The central data point required for the calculation of Indicator 2 is the location and the share of the respective entities that consume electricity. CCRI uses external data providers to gather location data of the nodes in the network. If for a network this data is not available, a world average is used.

Indicator 3 – Energy intensity

> "Average amount of energy used, in kWh, per validated transaction"
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

The MiCA regulation differentiates between the energy consumption for securing the integrity of the ledger and the energy consumption for validating transactions, as seen in Indicator 1. This distinction is important, as it highlights the need for a methodology to assess the energy consumption of a single transaction not merely by dividing the total consumption by the number of transactions, as this would indicate that the entire energy consumption is attributable to transactions.

For energy allocation, we define two types of activities in blockchain networks, namely transactions (either in the form of transaction count, transaction fees or gas consumption) and holdings (either in the form of the base unit or its monetary value in USD). Overall, there are three ways to allocate electricity consumption to these activities:

- **Holding-based approach**: The holding-based approach mandates us to calculate the electricity consumption per held unit. Therefore, we divide the total electricity consumption of the network by the total supply of the network, resulting in a value of electricity consumption per unit. The timeframe is defined by the timeframe of the electricity consumption, e.g., a day or a year. This approach does not consider transactions to be a driver of electricity consumption. Holding currencies can, especially in the case of PoW networks, be the main driver of electricity consumption. Holders are the entities that pay the mining reward in PoW networks, as the inflation of the currency is paid as a reward to the miners and impact all holders of the currency equally. That indirect payment allows the miners to continue their business and spend their rewards (partially) on electricity. The holding-based approach can be used in times of low or no transaction fees for miners and highlights the importance and cost of securing the ledger in contrast to the execution of transactions.
- **Transaction-based approach**: The transaction-based approach follows the simple approach, as previously described, to divide the total electricity consumption by the number of transactions that occurred during the same period of time. While this metric is easy to calculate, it is often misleading, as calculating this metric does not consider the nuances of the network, e.g., as Proof of Work does not only secure the execution of the current transactions, but also protects the integrity of the "non-moving" coins. Other networks that provide file storage would also need to distribute storage-related energy use to transactions without any logical connection whatsoever.

- **Hybrid approach**: The hybrid approach is a methodology[3] that has been developed to cater to new developments and insights in the crypto market, such as layer 2 networks or further consensus mechanisms.[4] The basic idea is to distribute the total electricity consumption between all activities in the network, both holdings and transactions. The respective shares can then be divided by the total amounts of the activities (such as total supply or transaction throughput), resulting in and creating individual metrics for each of the activities.

We use the hybrid approach, as a) it is in line with the MiCA regulation and b) provides fair and comparable metrics between different cryptocurrencies. The core of the hybrid approach is the split-up of the total electricity consumption, and there are, depending on the Consensus Mechanism, different ways to define these shares, depending on the drivers of electricity consumption.

For the **PoS networks** in scope, transactions are rather a small part of the total electricity consumption of the nodes, as the regular maintenance of the ledger consumes electricity regardless of the transaction throughput. Therefore, we use the marginal electricity consumption per transaction, which we calculated for Indicator 1, as a driver to discern between transactions and holdings, attributing the marginal electricity consumption to transactions and the remainder to the holders. More details can be found in the respective technical document.[5]

[3] https://carbon-ratings.com/accounting-framework-2022
[4] https://arxiv.org/abs/2111.06477
[5] https://arxiv.org/abs/2111.06477

b. GHG emissions

To derive the GHG emissions for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions, two components are required: (1) the energy consumption and (2) the emission intensity of the energy consumed. The first component has been derived in the previous section and now serves as a direct input for this section. The second component needs to be collected in accordance with established carbon accounting as we outline in the following subsections.

Indicator 4 – Scope 1- Controlled

> "Scope 1 GHG emissions, expressed in tonnes (t) carbon dioxide equivalent CO2e) per calendar year for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions"
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

For the fourth indicator, ESMA asks for scope 1 GHG emissions for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions. The distinction between the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions is analogous to the previous section on energy. However, special attention needs to be paid to the different scopes of the emissions.

The distinction of the emission in different scopes has been introduced by the GHG Protocol which provides guides for carbon accounting at the corporate level.[6] Scope 1 is defined as direct GHG emissions from sources that are owned or controlled by the company. As a crypto-asset is not a company, the distinction in emission scopes may seem somehow misleading in this context. We would argue that a reasonable interpretation would be to think of the GHG emissions that are owned or controlled by the ones who validate transactions and maintain the integrity of the distributed ledger transactions (i.e., validators). As the GHG emissions for the validation of transactions and the maintenance of the integrity of the distributed ledger occur during the production of the electricity that is consumed, the GHG emissions would only be owned or controlled by the miners or validators in case they are producing the electricity themselves. For Proof of Work currencies, large mining companies that need vast amounts of energy could run their own power plants. However, this does not relate to validators of PoS networks. As CCRI has found no indication of validators of the networks in scope having their own power plants, we assume that validators are purchasing the electricity they use (which represents scope 2 – see indicator 5).

Indicator 5 – Scope 2- 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"
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

[6] https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

For the fifth indicator, ESMA asks for scope 2 GHG emissions for the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions. Also in this case, the distinction between the validation of transactions and the maintenance of the integrity of the distributed ledger of transactions is analogous to the previous section on energy. Scope 2 is defined as indirect GHG emissions from emissions from the generation of acquired and consumed electricity.[7] In line with indicator 4, we assume the indirect GHG emissions of the acquired and consumed electricity of validators. The GHG Protocol presents two complementary methods to report scope 2 emissions:

- **Location-based method:** It reflects the average emissions intensity of grids on which energy consumption occurs (using mostly grid-average emission factor data). Therefore, the method requires the amount of electricity consumed at each location (see indicator 2 for an overview) as well as the respective grid-average emission factors which are often published by state authorities (e.g., by the United States Environmental Protection Agency for U.S. states).
- **Market-based method:** It reflects emissions from the electricity that companies have purposefully chosen (or their lack of choice). It derives emission factors from contractual instruments, which include any type of contract between two parties for the sale and purchase of energy bundled with attributes about the energy generation, or for unbundled attribute claims. As such, the market-based method does not only require information on the contractual instrument used (as well as associated credible claims) but also emission factors representing the untracked or unclaimed energy and emissions (termed the "residual mix") for the share of electricity for which there is no contractual information that meets the Scope 2 Quality Criteria.

The GHG Protocol requires both methods to be reported separately if one decides to start calculating scope 2 emissions with the market-based method (termed "dual reporting"). The market-based method was introduced as a complement to the location-based method. As there is no data on the energy type that validators consume and respective proofs (e.g., through renewable energy certificates), CCRI relies purely on a location-based method.

Indicator 6 – GHG intensity

> "Average GHG emissions (scope 1 and scope 2) per validated transaction, expressed in kilogram (kg) CO2e per transaction (Tx)"
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

For the sixth indicator, ESMA asks for the average GHG emissions (scope 1 and scope 2) per validated transaction. We derive this metric in the same way as described for the average energy consumption per validated transaction required for Indicator 3.

[7] https://ghgprotocol.org/sites/default/files/2023-03/Scope%202%20Guidance.pdf

c. Waste production

Similar to the energy-related indicators, the first waste production-related indicator captures the total amount of electrical and electronic equipment waste for the validation of transactions and the maintenance of the integrity of the distributed ledger. Indicator 8 then quantifies the non-recycled share, and Indicator 9 the hazardous waste fraction. Further details are provided below for each of the indicators.

Indicator 7 – 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, expressed in tonnes per calendar year"
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

For the seventh indicator, ESMA asks for the total generation of waste electrical and electronic equipment. The generation of electronic waste is dependent on the hardware usage of the network and how fast devices are replaced – either because of hardware depreciation, performance issues, or implications on the revenue. Depending on the specifics of the hardware replacement, the calculation of the total electronic waste can be conducted in two consecutive steps:

1. **Understand the hardware composition and weight of devices**: As CCRI conducts its measurement on a reference hardware set, they assume these devices to be representative for this indicator as well. The weights of the individual devices as well as their share in the network is calculated, respectively.
2. **Define the depreciation time frame**: If we know the hardware composition for a given day in the network, we are able to calculate the WEEE generated on that day with a given depreciation time frame.[8] We assume that hardware devices depreciate over three years for Proof of Stake networks.

Indicator 8 – 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, expressed as a percentage."
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

For the eighth indicator, ESMA asks for the share of non-recycled WEEE. To calculate this metric, CCRI considers the location of validators (see indicator 2 for an overview) as well as the local recycling rates for WEEE at the respective locations. Similarly to energy sources and emission factors by country or region, local recycling rates can be obtained from state authorities or research

[8] Example: If a hardware device is deprecated over five years, then the generated WEEE of devices is calculated by the devices' weight divided by the total days the devices are in use (5 years = 1,825 days).

institutions specialized in the field (e.g., United Nations Institute for Training and Research (UNITAR), UNU-ViE Sustainable Cycles (SCYCLE), The International Telecommunication Union (ITU) jointly publishes reports monitoring e-waste production and recycling).

Indicator 9 – 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, expressed in tonnes per calendar year"
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

For the ninth indicator, ESMA asks for the hazardous waste generated by the network. As we calculated the waste component of the network already in indicator 7, CCRI builds upon that figure and calculates the hazardous waste as a share of the total electronic waste and provides a respective value expressed in tonnes per calendar year.

Hazardous waste is a term that is linked to European Union Guidelines "Waste Electrical and Electronic Equipment Directive (WEEE Directive)" (2012/19/EU) and Restriction of Hazardous Substances Directive (2011/65/EU, RoHS 2) which properly defines contents of electronic devices as hazardous substances, such as lead, mercury, cadmium, and others.

The calculation of the share of the hazardous substances is merely a question of proper data sources and diligence. We obtained a "Restriction of Hazardous Substances Directive Report" (RoHS Report), which needs to be published by respective vendors.[9] CCRI uses the contents of these documents for the calculation of the hazardous waste.

[9] For example, Intel produces such reports, e.g., for Intel NUCs: https://cdrdv2-public.intel.com/728760/xnuc11atkc4000x%20%20Declaration%20Form%20Build%20-%2068241.pdf

d. Natural resources

The last category aims to capture lifecycle impacts on natural resources beyond the aspects captured by the previous indicators. For the tenth indicator, ESMA asks for a description of the impact on natural resources of the production, the use and the disposal of the devices of the DLT network nodes. While ESMA asks for very concrete metrics for the other indicators by defining exact time periods and units, this indicator is only loosely defined as of now. Thus, there is reason to assume that this indicator may be more closely defined as ESMA publishes its final requirements for mandatory indicators (expected by the end of June 2024).

Indicator 10 – 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"
>
> *- ESMA, Consultation Package 2, Annex II, Table 1*

For the tenth indicator, CCRI provides a description of the general impact of the devices of DLT network nodes on natural resources, such as water, fossil fuels, and critical raw materials during the production, use, and disposal phase. Water consumption is heavily driven by the amount of energy consumed by the network as well as the regional water intensity of the electricity consumption. Thus, the energy consumption, the location of validators as well as regional electricity water footprint may serve as an input to assess the water consumption of a crypto-asset during the use phase following the approach which is taken by research papers investigating the water consumption of Bitcoin.[10]

[10] de Vries, Alex. "Bitcoin's growing water footprint." Cell Reports Sustainability 1.1 (2024).

Overview of data sources

The following data sources were used to generate the indicators for the currencies and tokens in scope as shown in the table on page 2.

General data sources:

- **Renewable electricity shares**: We use electricity generation mix data from IRENA (2023), Renewable energy statistics 2023, International Renewable Energy Agency, Abu Dhabi.
- **E-waste recycling shares**: We use e-waste recycling rates from The Global E-waste Monitor 2020 by UNI/UNITAR and ITU.
- **Emission factors**: We use emission factors from the Environmental Protection Agency for U.S. states, from the Environmental Energy Agency for European countries and from Climate Transparency for all other G20 countries.
- **Reference hardware set for PoS cryptocurrencies**: See here: https://docs.api.carbon-ratings.com/v2/#/mica?id=proof-of-stake-proof-of-authority-and-other-consensus-based-currencies (bottom of the page)

Currency-specific sources:

- **Alogrand**
  - Validator count: https://metrics.algorand.org/#/decentralization/
  - Location data: N/A, using world-average for the emission intensity, the renewable energy share, and the recycling share of the network
  - More details at: https://docs.api.carbon-ratings.com/v2/#/currencies
- **Avalanche**
  - Validator count: https://avascan.info/blockchain/c/info
  - Location data: https://avascan.info/
  - More details at: https://docs.api.carbon-ratings.com/v2/#/currencies
- **Polkadot**
  - Validator count: https://polkadot.subscan.io/validator
  - Location data: https://greenpolkadot.io/ (historical data, currently offline)
  - More details at: https://docs.api.carbon-ratings.com/v2/#/currencies
- **Ethereum**
  - Validator count: MonitorEth.io
  - Location data: MonitorEth.io
  - More details at: https://docs.api.carbon-ratings.com/v2/#/currencies
- **Solana**
  - Validator count: https://www.validators.app/
  - Location data: https://www.validators.app/
  - More details at: https://docs.api.carbon-ratings.com/v2/#/currencies
- **Stellar**
  - Validator count: https://stellarbeat.io/
  - Location data: https://stellarbeat.io/
  - More details at: https://docs.api.carbon-ratings.com/v2/#/currencies
- **Base**
  - Validator count: N/A, assuming 110 nodes (similar to Polygon)

- Location data: N/A, using world-average for the emission intensity, the renewable energy share, and the recycling share of the network
- Standard CCRI PoS L2 network assessment conducted for this report, see indicator descriptions.
- The coverage for base starts on June 15 2023, as the first transaction of the network took place on that date. Therefore, the related indicators are only covering the period from June 15 till EOY 2023.

- **Arbitrum**
  - Validator count: N/A, assuming 110 nodes (similar to Polygon)
  - Location data: N/A, using world-average for the emission intensity, the renewable energy share, and the recycling share of the network
  - Standard CCRI PoS L2 network assessment conducted for this report, see indicator descriptions.
- **Optimism**
  - Validator count: N/A, assuming 110 nodes (similar to Polygon)
  - Location data: N/A, using world-average for the emission intensity, the renewable energy share, and the recycling share of the network
  - Standard CCRI PoS L2 network assessment conducted for this report, see indicator descriptions.
- **Noble**
  - Validator count: https://www.mintscan.io/noble/validators
  - Location data: N/A, using world-average for the emission intensity, the renewable energy share, and the recycling share of the network
  - We have developed a model for sustainability metrics of Cosmos network chains in https://carbon-ratings.com/dl/pos-report-2023. We used this model and applied it to Noble's individual properties.

Token-specific sources:

Except for the network / token combinations below, transaction data are collected from the respective blockchain networks.

- **USDC on Noble:**
  - USDC is the native asset of the Noble blockchain and no other asset is currently part of the network (see https://nobleassets.xyz/ -> Assets). Therefore, the token-specific allocation to the USDC token on noble is identical to the Noble chain itself.
- **EURC on Base**:
  - **Transaction count**: As EURC on Base is not yet launched, we use the average transaction count from all other EURC deployments as a proxy.