2 Methodologies

In the following subsections, the methodologies for the calculation of cryptocurrencies are shown. In addition to the methods proposed by 21Shares, the methods recommended by myclimate are also briefly presented.

2.1 21Shares Methodology

21Shares provided a methodology paper to calculate the carbon emissions per transaction for different cryptocurrencies (21shares, 2021). There are two methods, which cover the cryptocurrencies BTC and ETH on the one hand and the three cryptocurrencies BCH, ETC and LTC on the other hand. All other cryptocurrencies are determined based on literature values.

2.1.1 BTC & ETH

The annual electricity consumption of the BTC network will be calculated per day based on hash rate of the particular date and then divided by the number of daily BTC transaction. The resulting electricity consumption per transaction is then multiplied by a global emission factor (21shares, 2021; IEA, 2021; Digiconomist, 2021). The same method is applied for ETH:

1) $$\frac{Total\ annual\ electrcity\ consumption}{365} = Total\ daily\ electricity\ consumption = \frac{TWh}{d}$$

2) $$\frac{Total\ daily\ electricity\ consumption}{Total\ daily\ transactions} = \frac{Electricity\ consumption}{Transaction} = \frac{TWh}{Tx}$$

3) $$\frac{Electricity\ consumption}{Transaction} * Global\ emission\ factor\ = Carbon\ emissions\ per\ Tx = \frac{kgCO_2}{Tx}$$

2.1.2 BCH, ETC & LTC

To get the carbon emissions per transaction, first the number of mining machines is calculated and then multiplied with the electricity consumption of such a machine to get the daily electricity consumption per cryptocurrency network. Second, the total daily electricity consumption is divided by the total daily transaction and multiplied by a global emission factor (IEA, 2021).

1) $$\frac{Total\ daily\ hash\ rate}{Hashrate\ of\ the\ equipment} = number\ of\ machines$$

2) $$Number\ of\ machine * \ Electricty\ consumption\ machine = Total\ daily\ electricity\ consumption$$

3) $$\frac{Total\ daily\ electricity\ consumption}{Total\ daily\ transaction} * Global\ emission\ factor\ = \ Emissions\ per\ Tx = \frac{kgCO_2}{Tx}$$

2.1.3 Other cryptocurrencies

For all other cryptocurrencies, which are staked according to PoS or a similar method, literature values from the Internet are used. 21Shares has defined the following values and calculation for the other 8 cryptocurrencies (Table 2):

Table 2: Literature values for ADA, XRP & XLM for kWh/Tx or $kgCO_2$/Tx.

Cryptocurrency	Value	Unit	Reference
ADA	0.5479	kWh/Tx	(TRG Datacenters, 2021)
XRP	0.0079	kWh/Tx	(XRP LEDGER, 2021)
XLM	0.000015	$kgCO_2$/Tx	(Brett, 2018)

XTZ

XTZ is reported to consume 60 MWh annually. This is then divided by 365 days and further by the daily transactions to get the kWh per transaction rate (21shares, 2021; TQ Tezos, 2021).

ATOM

ATOM is reported to consume 0.00046647 TWh annually. This is then divided by 365 days and further by the daily transactions to get the kWh per transaction rate (COSMOS, 2021; 21shares, 2021).

EOS

EOS is reported to consume 3196 kWh per day, which is then divided by the daily transactions to get the kWh per transaction rate (GENEROS, 2018; 21shares, 2021).

BNB

BNB elects 21 validators and each validator uses servers such as google cloud (or similar) which on average, consume around 44.5 kWh per user per year. This is divided by the total energy consumption and further by daily transactions to get the kWh per transaction rate (Binance, 2021; 21shares, 2021).

DOT

DOT elects 297 validators and each validator uses an i7-7700k CPU (or similar) which consumes around 2.184 kWh. This is divided by the total energy consumption and further by the daily transactions to get the kWh per transaction rate (Polkadot Network, 2021; Polkadot Wiki, 2021; 21shares, 2021).

2.2 myclimate Methodology

To verify the results of the 21Shares methodologies, myclimate has conducted its own calculations of the GHG emissions per transaction for the different cryptocurrencies. These calculations serve as a plausibility check of the methods applied by 21Shares and can be further extended to include improvements. In the case of the 8 cryptocurrencies, which are based on literature values (2.1.3), a rather pragmatic approach is taken to determine the emissions, which will then serve as the basis for carbon offsetting.

2.2.1 BTC, ETH, BCH, ETC & LTC

For these 5 cryptocurrencies the same methodology or calculation approach is taken. The methodology used by 21Shares for calculation the carbon footprint of BCH, ETC, and LTC is used as a basis, but has been extended to include all relevant GHG emissions. In addition to the formula in section 2.1.2, the Power usage effectiveness (PUE) was applied and the emissions for the production and disposal of the IT infrastructure were added. Note that this methodology was applied for a period of one month. However, this method can also be applied for a longer or shorter period. In addition, please note that for the emission factor of the electricity, a geographical distribution of the miners was taken if available. If this was not available, a global electricity mix was used for the emissions calculations.

1) $$\frac{Total\ daily\ hash\ rate}{Hashrate\ of\ the\ equipment} = number\ of\ machines$$

2) $$Number\ of\ machine * Electricty\ consumption\ machine * PUE = Total\ daily\ electricity\ consumption$$

3) $$\frac{Total\ daily\ electricity\ consumption}{Total\ daily\ transaction} * Global\ emission\ factor = Carbon\ emissions\ per\ Tx = \frac{kgCO_2}{Tx}$$

4) $$Emissions\ electricity\ per\ Tx + Emission\ IT\ infrastructure\ per\ Tx + Emissions\ disposal\ per\ Tx = Final\ carbon\ emissions\ per\ Tx = \frac{kgCO_2e}{Tx}$$

2.2.2 Other cryptocurrencies

For the remaining cryptocurrencies, a very pragmatic approach was taken for the convenience of providing the necessary basis for a carbon offset. Basically, a general electricity consumption per transaction is multiplied by a global emission factor to get the greenhouse gas emissions per transaction. This approach is possible because these cryptocurrencies work with the PoS consensus mechanism and thus have been shown to require less energy than the PoW mechanism (Platt & Sedlmeier, 2021). Moreover, the production of the IT infrastructure and its disposal are negligible for these cryptocurrencies.

1) $$Electricity\ consumption\ per\ Tx * Global\ emission\ factor = Emission\ per\ Tx = \frac{kgCO_2e}{Tx}$$