Impact of Bitcoin Price & Complexity on CO2 Emissions

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Introduction

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Blockchain

02

What is Bitcoin?

03

Bitcoin Mining

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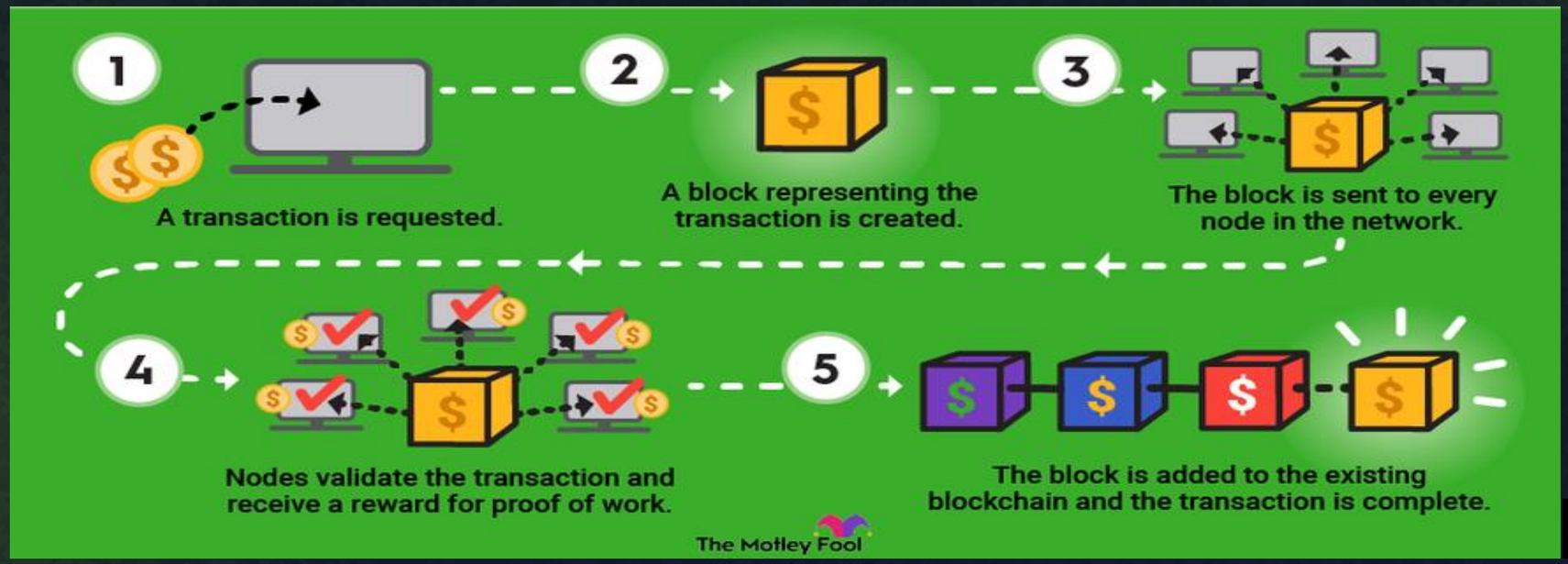
Environmental Impact

Blockchain

- Blockchain is a type of database that stores information in blocks that are linked together.
- Transactions are recorded on a blockchain, which is a distributed and immutable ledger.
- Each transaction is verified by a network of participants (miners) rather than a central authority.



Source

What is Bitcoin?

- First introduced in 2009 by an anonymous person or group using the pseudonym Satoshi Nakamoto.
- It is a decentralized, digital currency exchanged through a peer-to-peer network without centralized authorities.
- One of the earliest and most well-known cryptocurrencies.
- Uses blockchain technology to secure and verify transactions.

Bitcoin Mining

Mining Process

Bitcoin miners compete to solve complex cryptographic puzzles. The first miner to find a valid solution gets to add a new block of transactions to the blockchain.

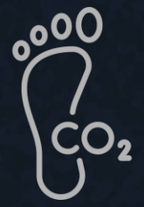
Proof of Work (PoW)

Bitcoin’s consensus mechanism relies on PoW, where miners expend computational power to validate transactions. This process ensures security and prevents double-spending.

Energy Consumption

Mining requires powerful machines (ASICs) that consume significant electricity. The more miners participate, the higher the energy consumption.

Environmental Impact



Carbon Footprint

Bitcoin mining has a substantial carbon footprint. A 2022 report estimated that it may be responsible for 65.4 mega tonnes of CO_2 emissions annually.

Energy Intensity

The energy-intensive mining process contributes to climate change. Miners often rely on fossil fuels, exacerbating environmental concerns.

Comparison to Gold

Bitcoin’s climate damage, relative to its market value, has averaged 35% over the past five years, comparable to gold mining.

Rationale for Analysis

- **Environmental Impact:** Assessing the environmental consequences of Bitcoin mining activities is crucial for evaluating its sustainability and identifying potential mitigation strategies.

- **Market Dynamics:** Analyzing how changes in Bitcoin prices correlate with fluctuations in CO2 emissions can provide insights into the factors driving cryptocurrency markets.

- **Policy Implications:** Insights gained from this analysis can inform policymakers and regulators about the need for targeted interventions to address the environmental impact of cryptocurrency mining.

Primary Objectives

01

To examine the historical trends of Bitcoin prices and CO2 emissions associated with Bitcoin mining.

02

To investigate the potential correlation between changes in Bitcoin prices and variations in CO2 emissions.

03

To assess the implications of the findings for environmental sustainability and cryptocurrency markets.

Scope of Analysis

Focus

Relationship between Bitcoin prices & CO2 emissions from Bitcoin mining activities

Limitations

While other environmental impacts of cryptocurrencies, such as e-waste generation, are also significant, they are beyond the scope of this analysis

Methodology

We have primarily utilized historical data and statistical methods to explore the relationship between Bitcoin prices and CO2 emissions

Methodology

Data Cleaning and Processing

Exploratory Data Analysis

Statistical Modeling

Interpretation of Findings

Data Sources

Bitcoin Data

- Bitcoin price - https://data.nasdaq.com/data/BCHAIN/MKPRU-bitcoin-market-price-usd
- Bitcoin difficulty - https://data.nasdaq.com/data/BCHAIN/DIFF-bitcoin-difficulty
- Bitcoin Hashrate - https://data.nasdaq.com/data/BCHAIN/HRATE-bitcoin-hash-rate
- Country Hasrate - https://ccaf.io/cbnsi/cbeci/mining_map

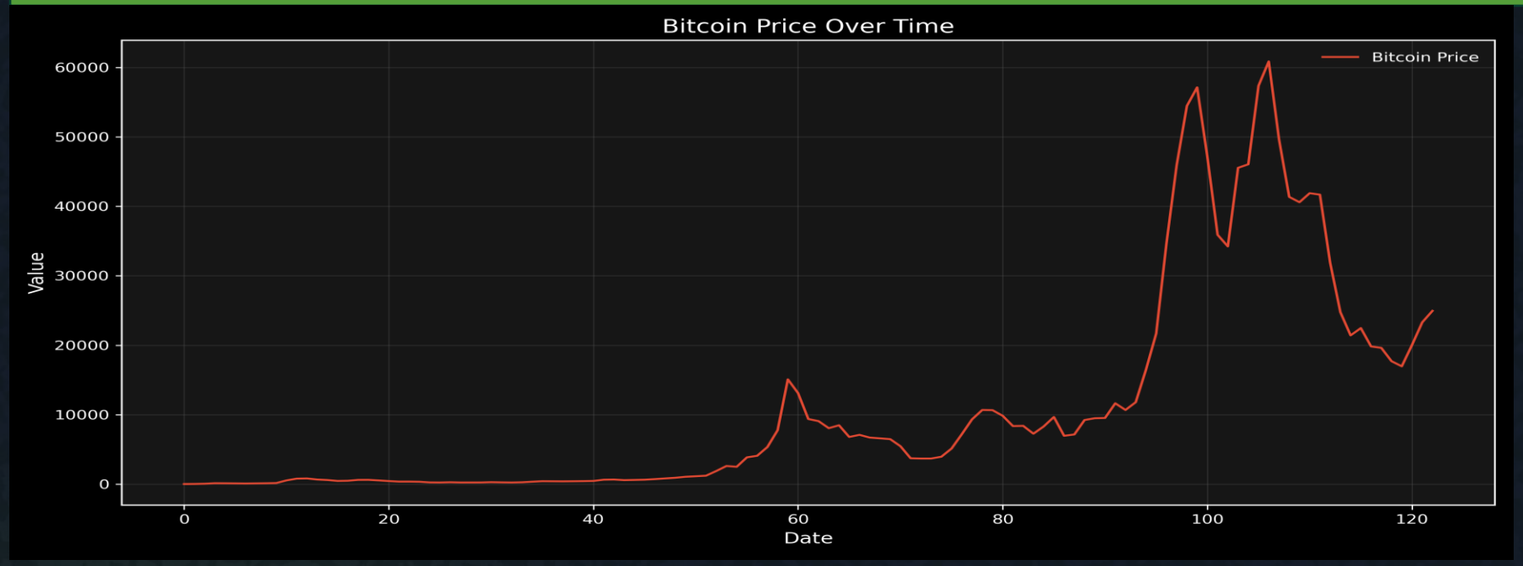
CO2 Emissions Data

- https://www.nature.com/articles/s41598-022-18686-8#MOESM1

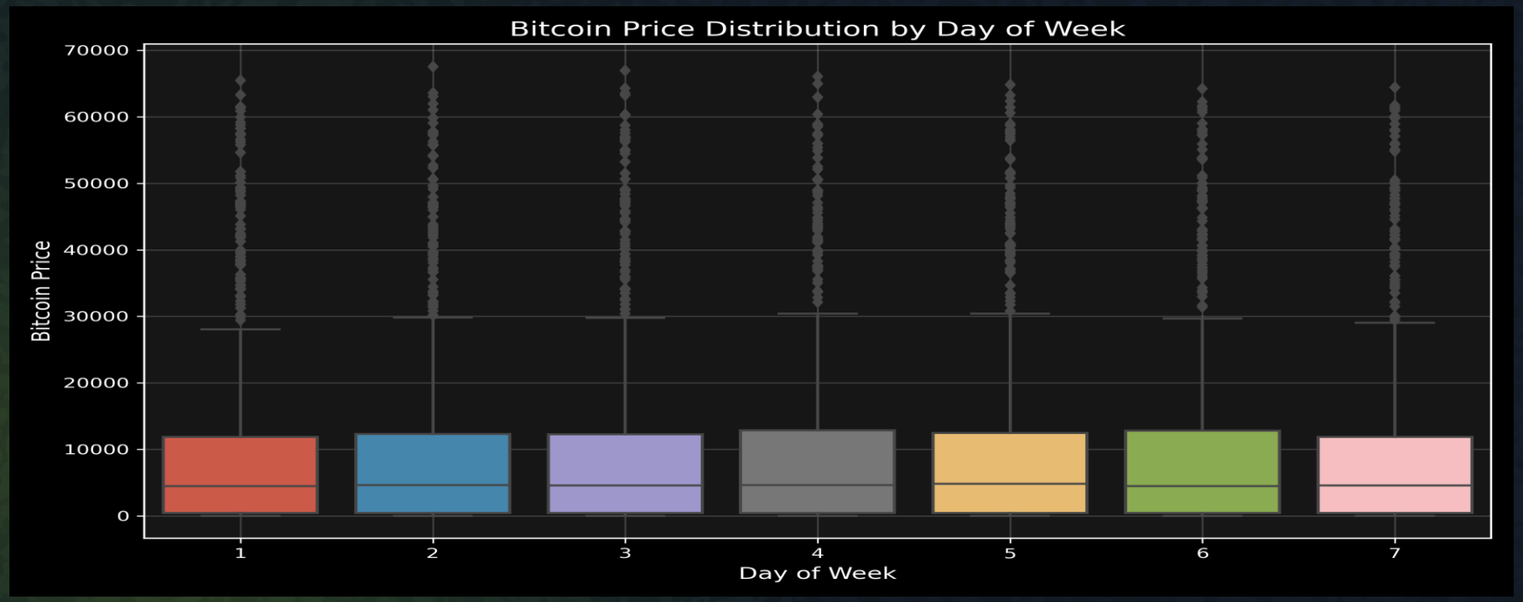
Other Data Sources

- https://code.earthengine.google.com/7b4aac9b43c339db67b8b8fec64ef18f

Historical Trends – Bitcoin prices over the years

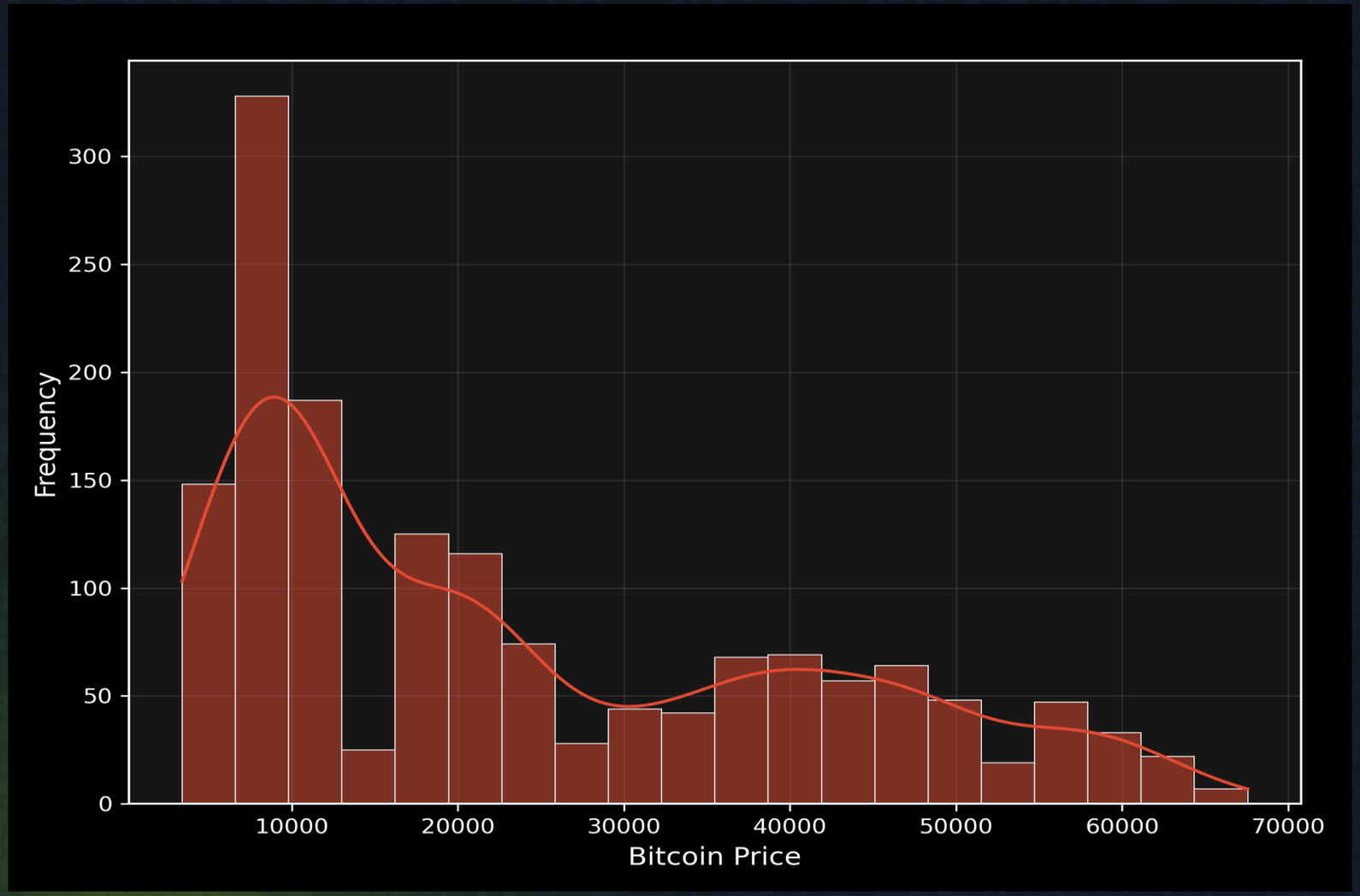


- The graph shows significant fluctuations in Bitcoin prices over time, with periods of rapid appreciation followed by periods of correction or consolidation.
- Despite short-term fluctuations, the general trend of the graph is upward, indicating a long-term appreciation in the value of Bitcoin
- Patterns in the graph also reflect investor behavior, including FOMO (fear of missing out) during price rallies and panic selling during downturns.



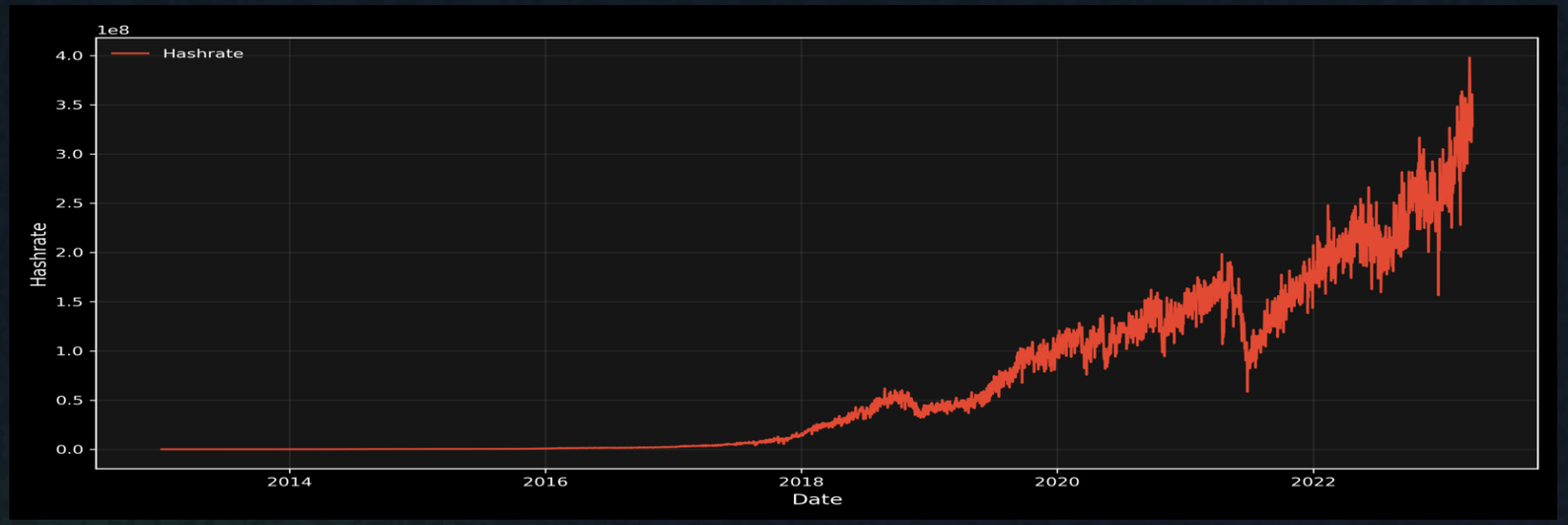
- **Consistent Range:** Throughout the week, there is a relatively consistent range in Bitcoin prices. There are no significant spikes or drops on any specific day.
- **Median Price Stability:** The median price remains relatively stable across all days. This suggests that there is no strong day-of-the-week effect on Bitcoin prices.
- **Outliers:** Some outliers are visible above each boxplot, indicating specific instances where Bitcoin's price was significantly higher than usual for that day.

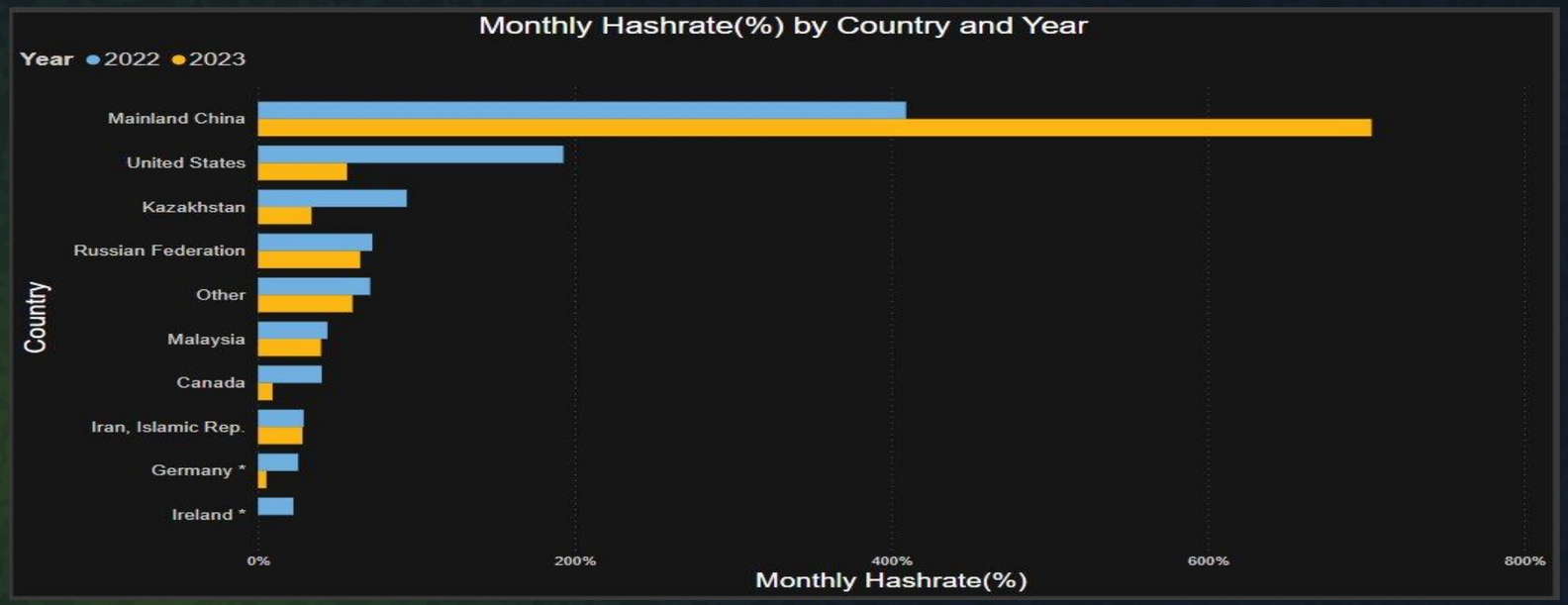
Historical Trends – Bitcoin Price distribution since 2018



- There is a prominent peak at the beginning of the graph, indicating that most observations are clustered around the 10,000 price point.
- Another smaller peak is present around the 40,000 price point.
- As we move right along the x-axis, the frequency decreases, suggesting fewer observations at higher prices.
- Overall, the distribution appears to be skewed, with more occurrences at lower price levels.

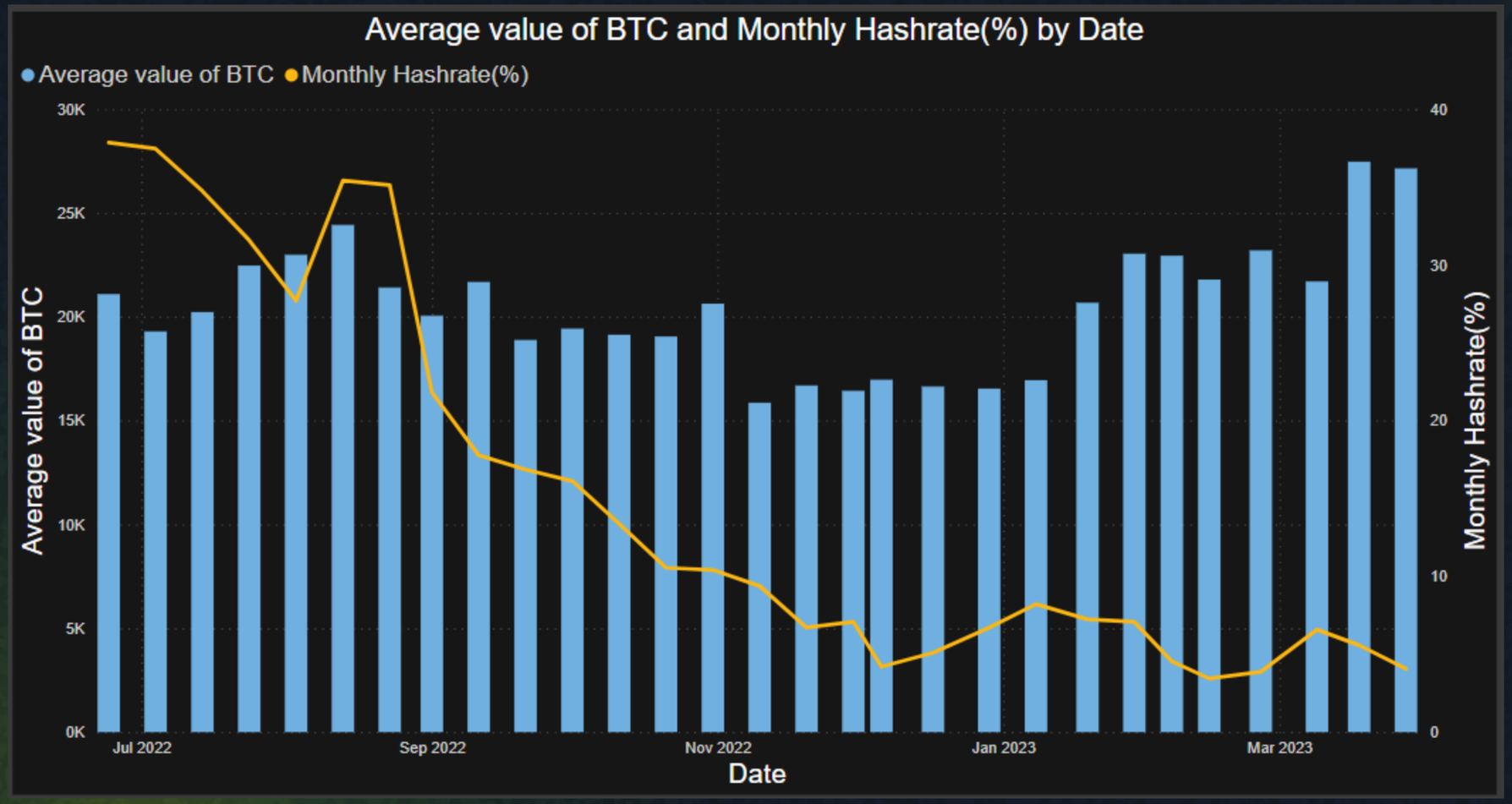
Historical Trends – Bitcoin Hashrate





- From 2014 to around mid-2018, the hashrate remains relatively low and stable.
- Post-mid-2018, there is a noticeable and consistent increase in the hashrate, with some fluctuations but an overall upward trend.
- This upward trend suggests that more computing power is being dedicated to mining Bitcoin, which contributes to the network's security and efficiency.
- China's share of bitcoin hashrate has increased from 2022 to 2023

Historical Trends – Bitcoin Hashrate



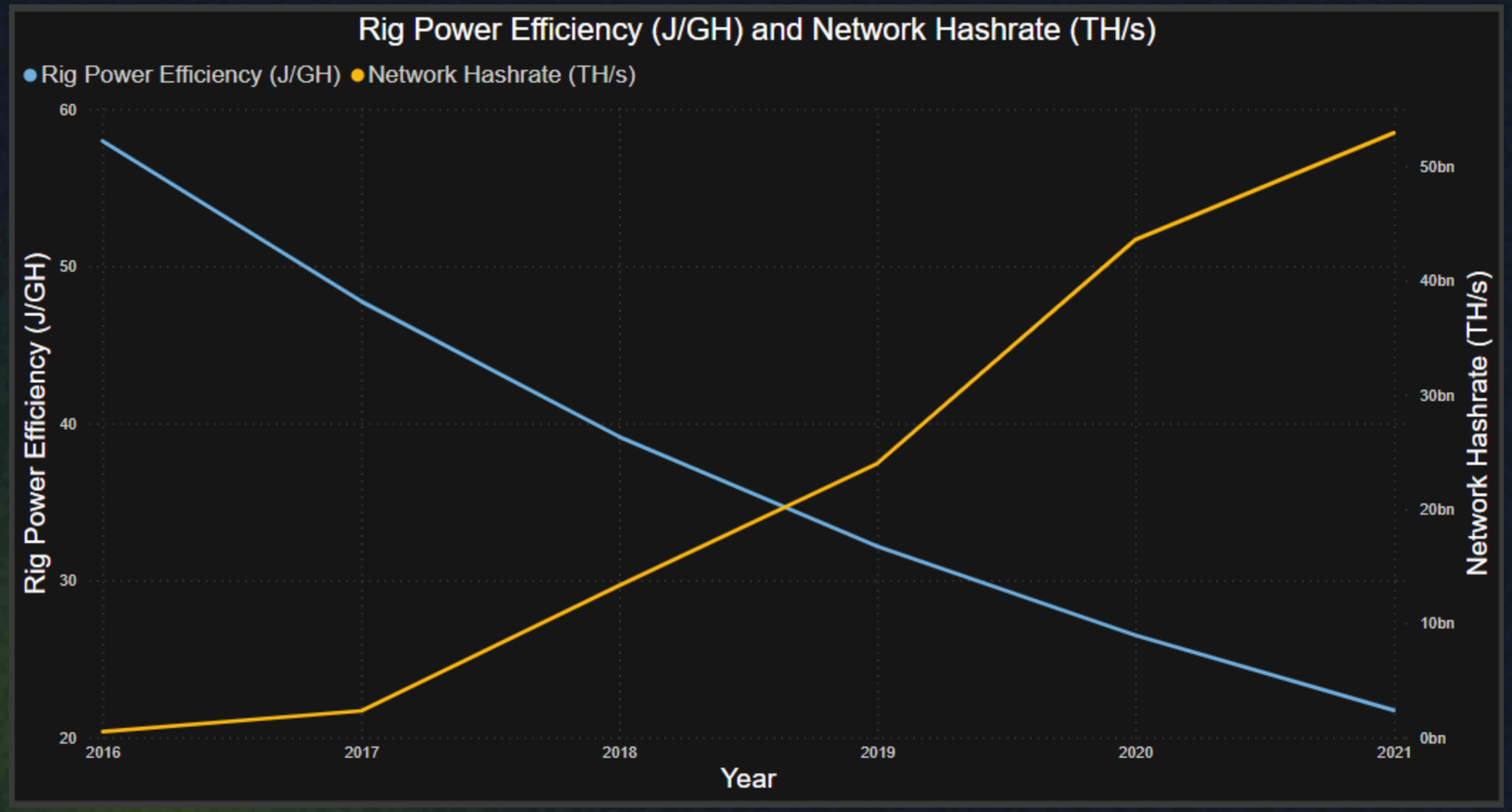
BTC Value:

- The yellow line graph represents the average value of BTC.
- It peaked in September 2022 at approximately $25,000.
- Post-November, it showed a decline with slight fluctuations.

Monthly Hashrate:

- The blue bars represent the monthly hashrate percentage.
- It also peaked in April 2023, almost reaching the top of the chart.

Historical Trends – Bitcoin Hashrate

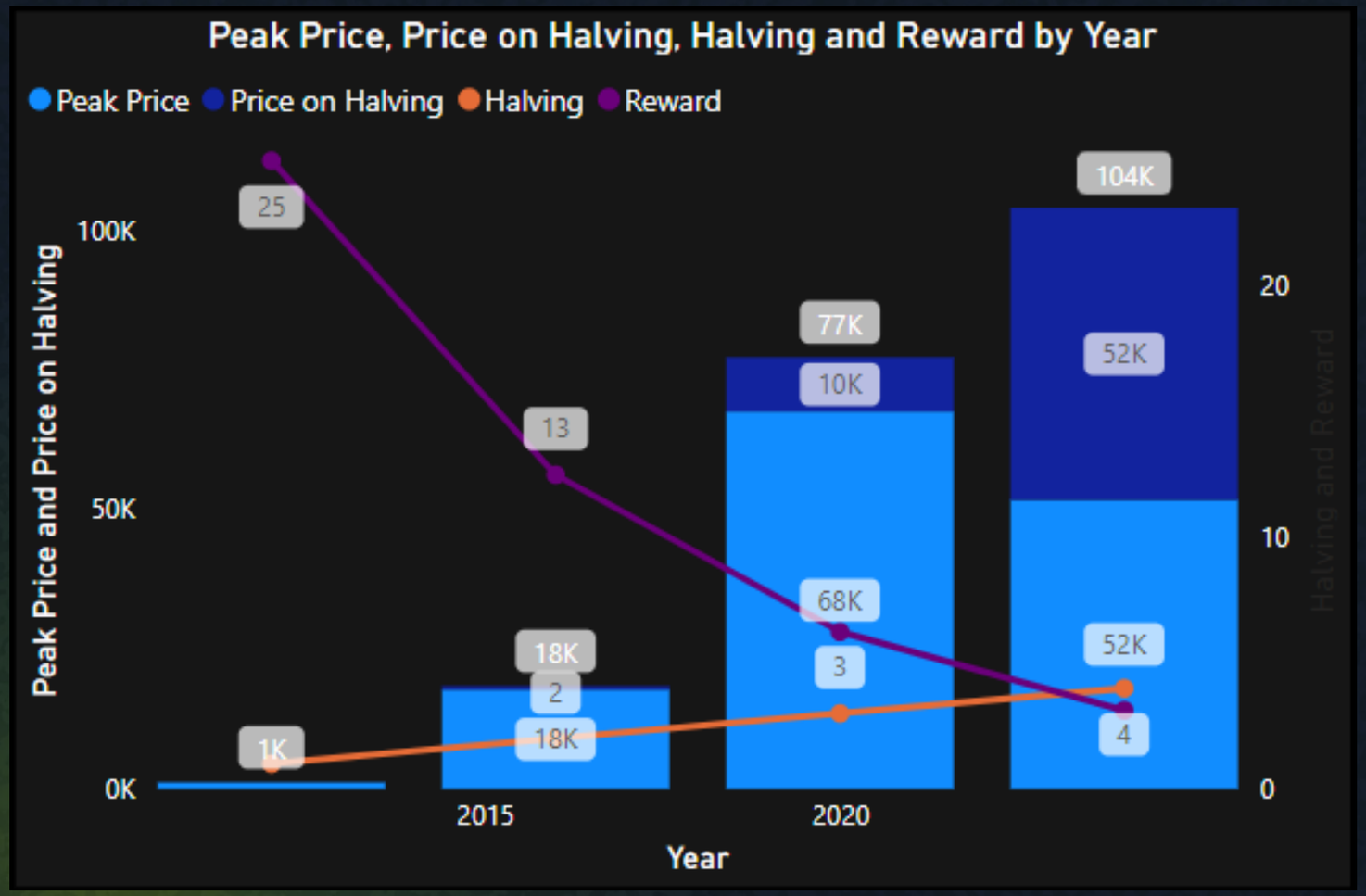


•**Rig Power Efficiency (J/GH)**:
Indicates how efficiently mining rigs convert energy into computational power (hashrate).
Over the years, rig power efficiency has decreased, implying that rigs are becoming less power-efficient.

•**Network Hashrate (TH/s)**:
Represents the total computing power used in cryptocurrency mining.
It has increased significantly, indicating a growing network of miners and more computational resources dedicated to mining.

•While rigs are becoming less efficient, the overall network hashrate continues to rise, reflecting the ongoing expansion of the cryptocurrency mining industry.

Historical Trends – Bitcoin Halving

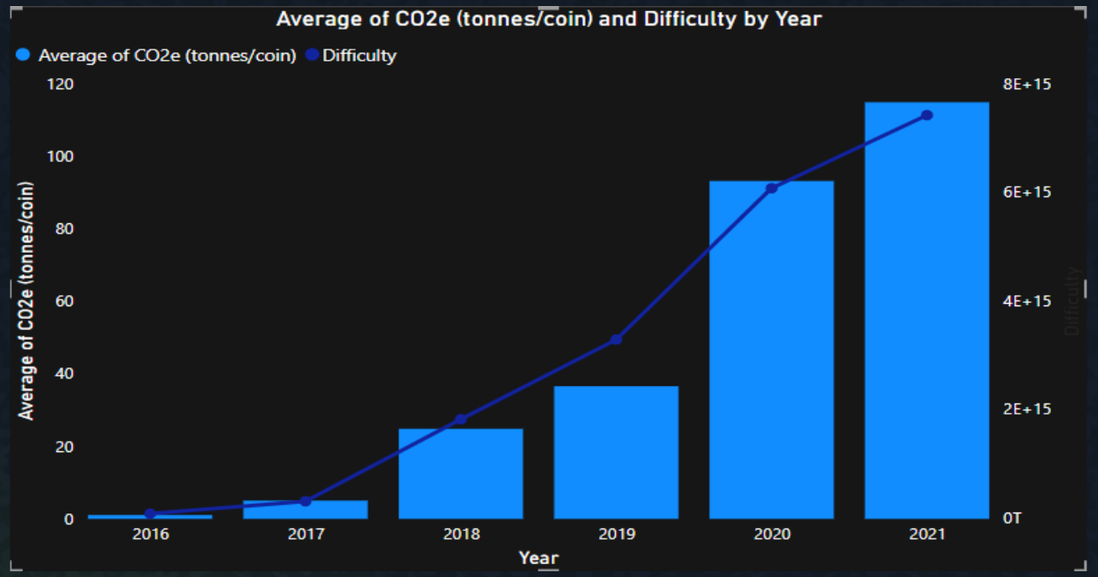


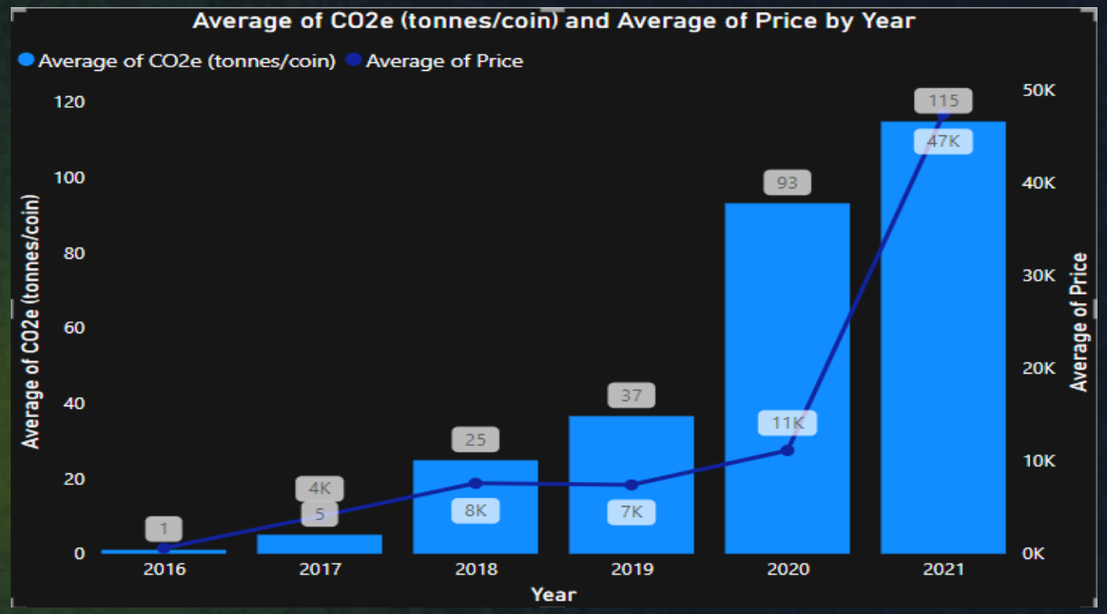
- Prices tend to increase significantly over time, especially after each halving event, which reduces the supply of new coins.
- The graph suggests that there is a positive correlation between the hashrate and the price, as the miners are incentivized to invest more resources and compete for the scarce reward.
- The graph shows how the cryptocurrency price and reward change over time in four-year cycles of three phases: accumulation, expansion, and contraction.
- The cryptocurrency is now in the contraction phase and will halve its reward in 2024.

Historical Trends – Bitcoins Created

- As the network hashrate increases, more miners participate in the process of mining new blocks.
- However, the total number of bitcoins created per day remains fixed due to the halving events (approximately every 210,000 blocks).
- With more miners competing for the same fixed reward, each miner's share of newly created bitcoins decreases.
- Therefore, despite the higher overall hashrate, individual miners receive smaller rewards, leading to a reduction in daily bitcoin production

Historical Trends – Bitcoin price vs CO2 emissions





- The graphs suggest that cryptocurrency mining is becoming more energy-intensive and less profitable over time, as the miners have to invest more resources and compete harder for the scarce reward.
- The CO2 emissions reflect the amount of electricity consumed by the mining equipment, which mostly relies on fossil fuels.
- The difficulty is a measure of how hard it is to find a valid block, and it is adjusted periodically based on the network hashrate.

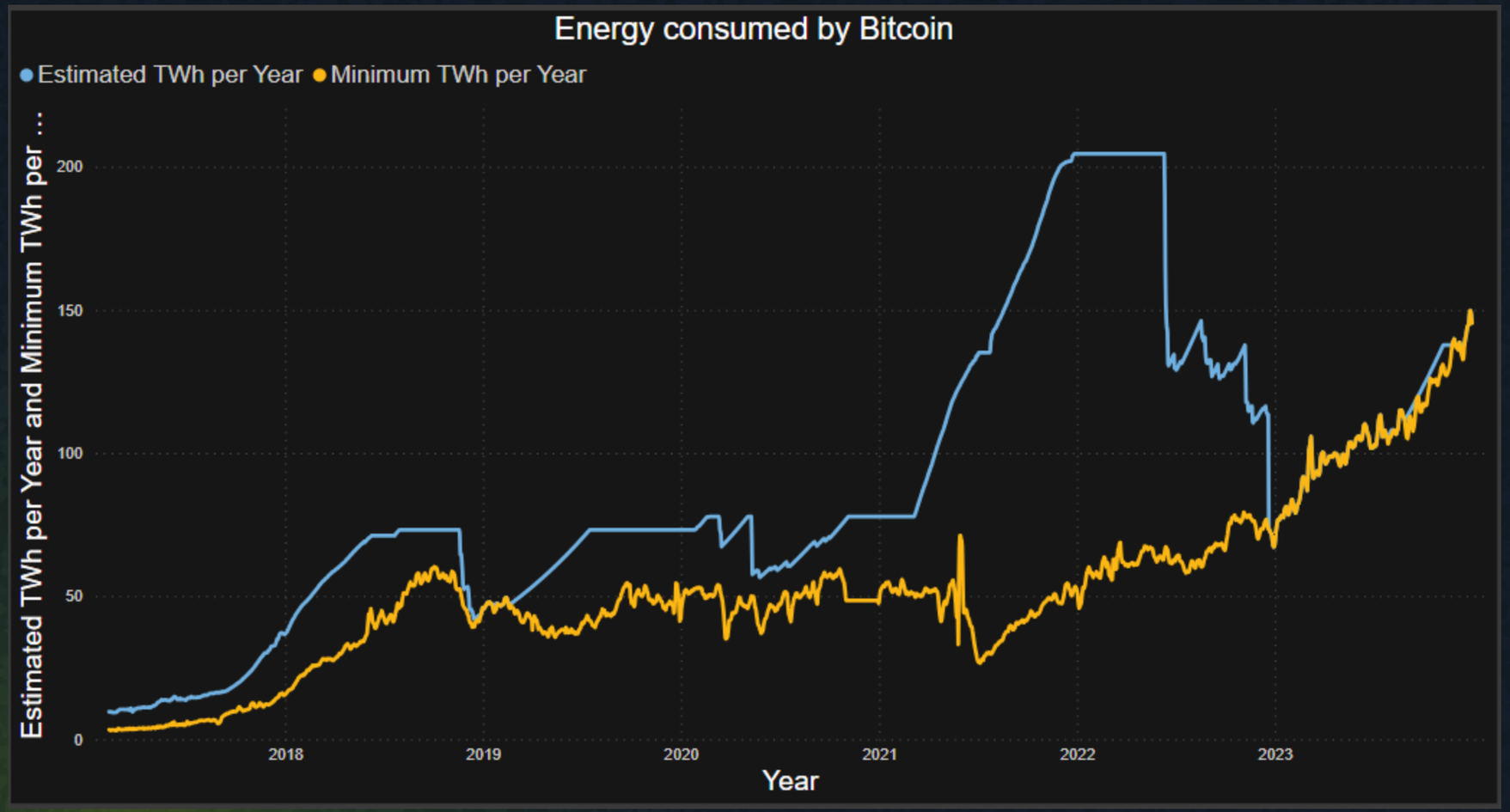
Historical Trends – Energy Consumption vs CO2 Emissions

- **Overall Trend**:
  The graph indicates that CO2 emissions remains relatively constant while energy consumption per bitcoin have risen significantly after 2018.

- Now, CO2 emissions here are only from 1 power plant but the energy consumption is the amount of energy required to mine 1 Bitcoin (which is constant around the world)

- So, after the next halving even more energy will be required to mine 1 bitcoin which in turn would lead to more CO2 emissions
- Further analysis would be needed to understand the specific factors contributing to this trend.

Historical Trends – Energy Consumption



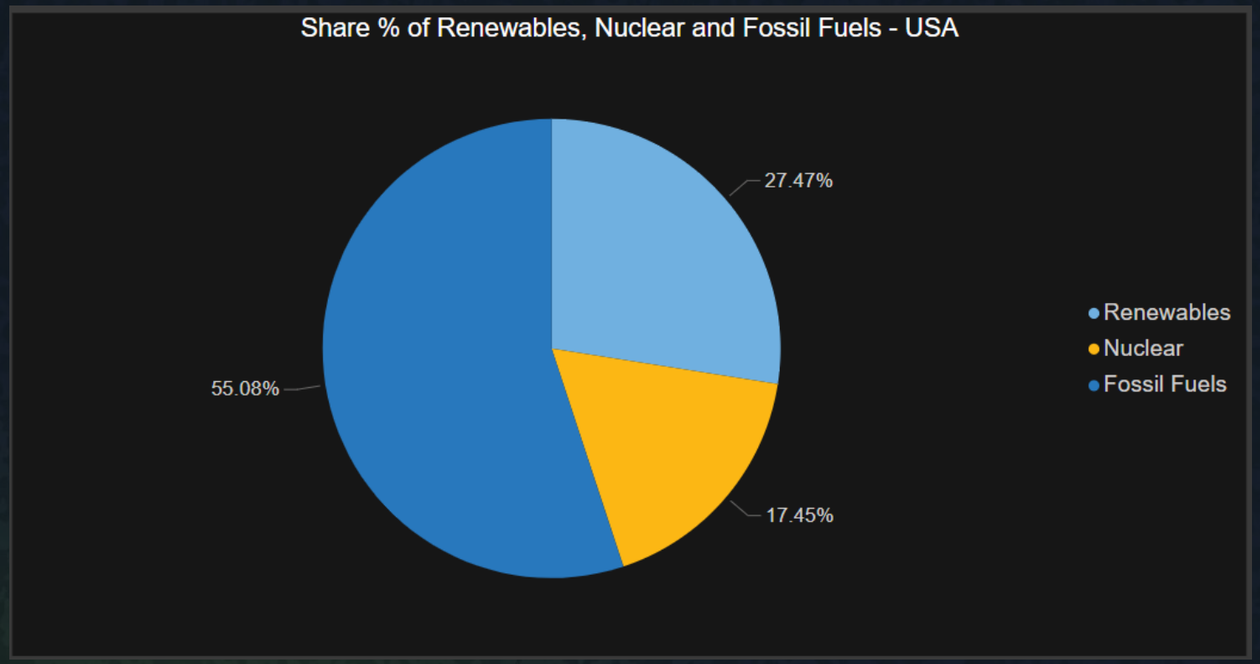
- **Estimated TWh per Year**: Represents the upper bound of energy consumption. It shows a general upward trend, with a significant spike around 2021.

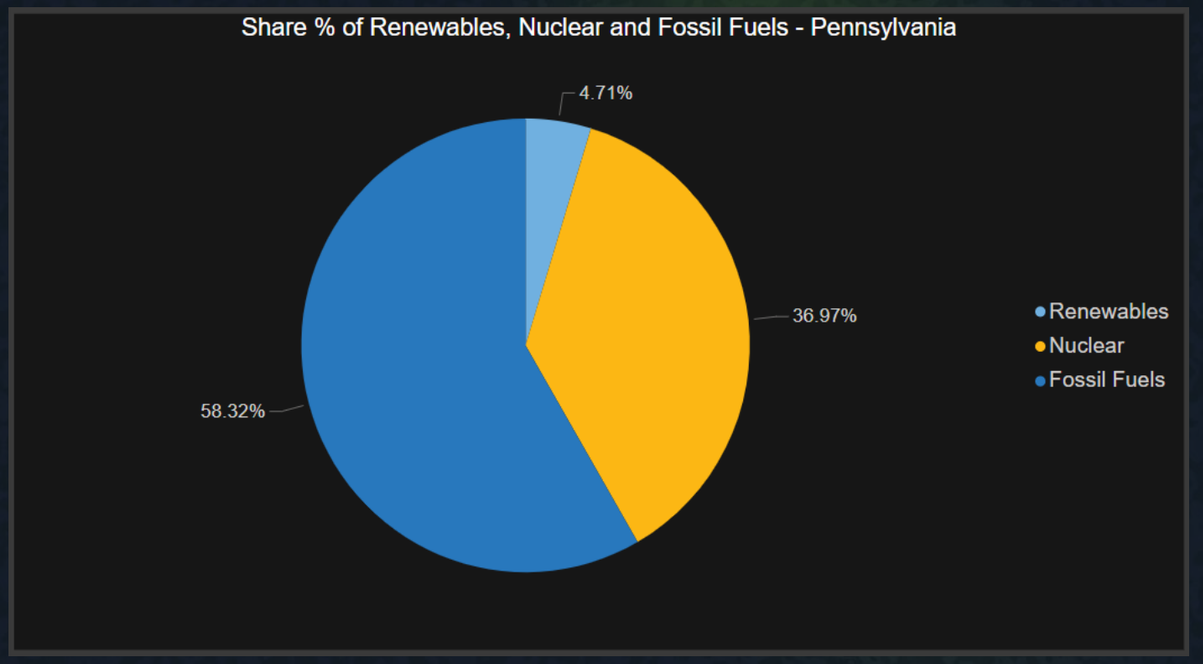
- **Minimum TWh per Year**: Represents the lower bound of energy consumption. It follows a similar pattern but with less variation.

- Both lines indicate an overall increase in energy consumption, with fluctuations over time.

- The sharp decline after the 2021 peak suggests efforts to reduce Bitcoin's environmental impact. However, energy consumption remains a critical concern for the cryptocurrency industry.

Distribution of Power Resources

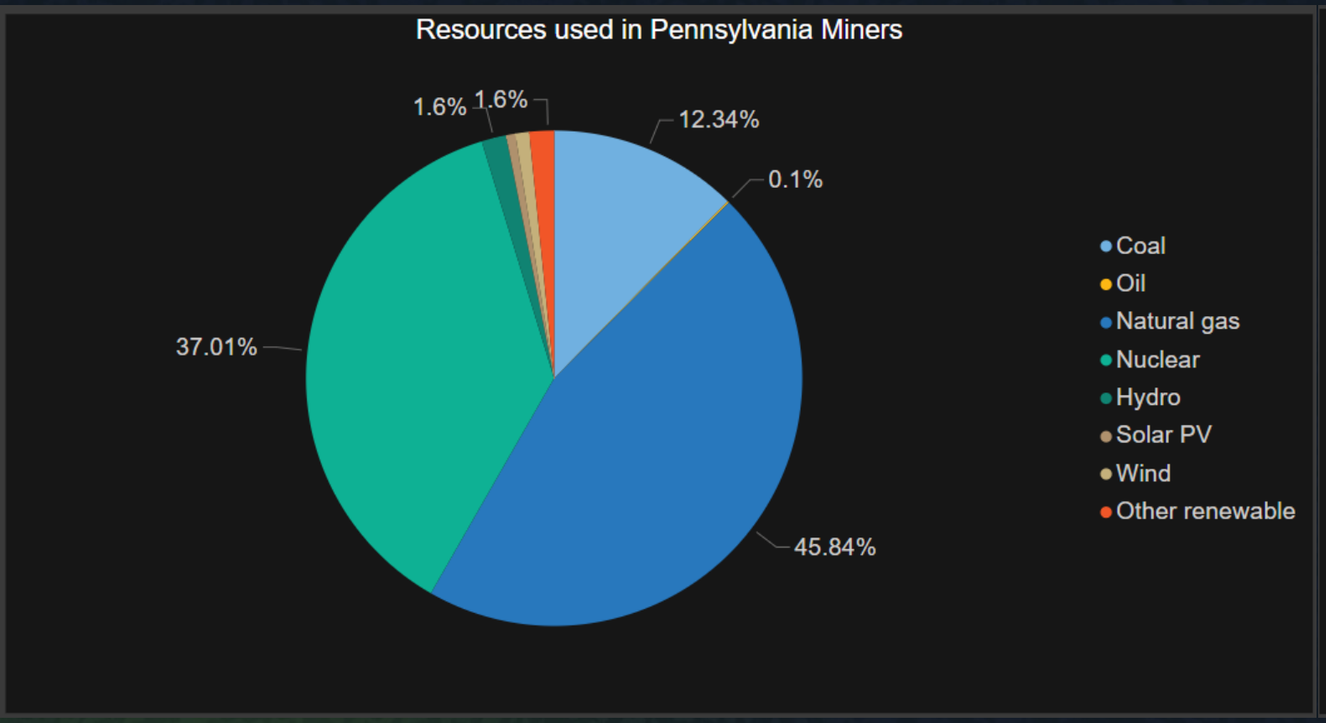


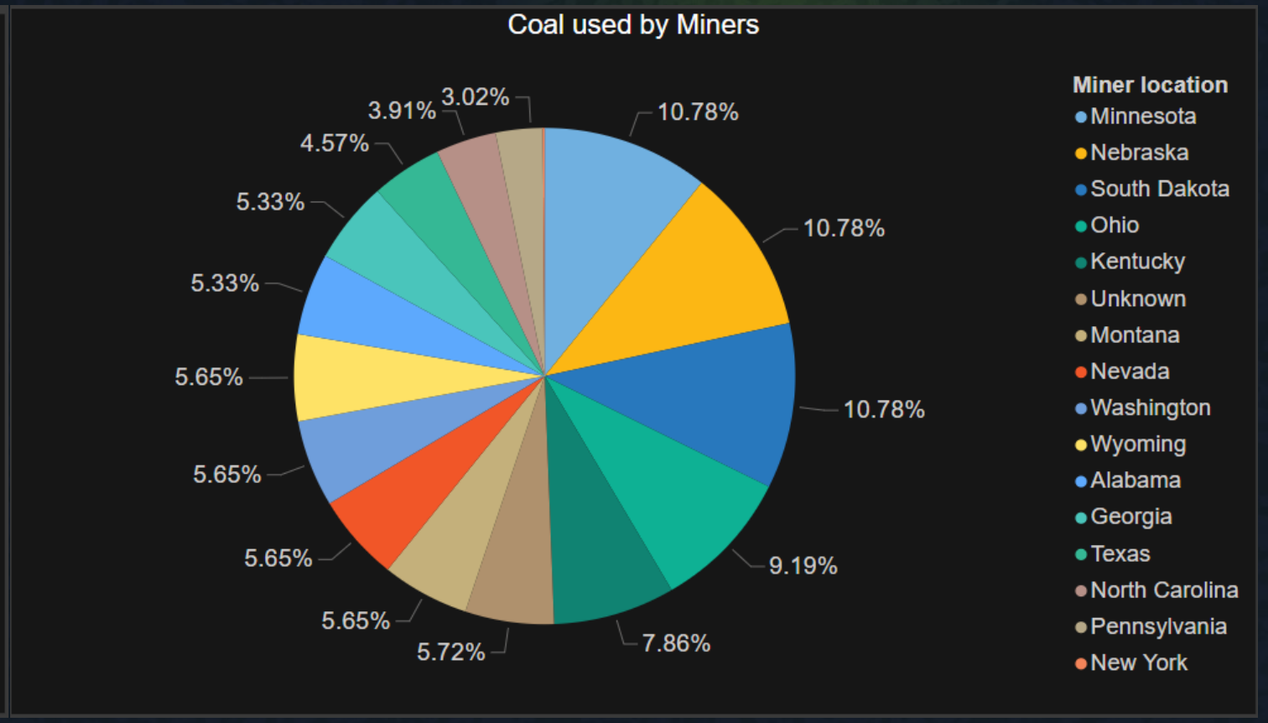


•In the United States, renewables contribute to 17.45% of the total energy generation, while nuclear energy accounts for 27.47%, and fossil fuels dominate with 55.08%.

•However, in Pennsylvania, renewables have a smaller share at 4.71%, while nuclear energy holds a larger portion at 36.17%, and fossil fuels remain dominant with 59.12% of the energy generation.

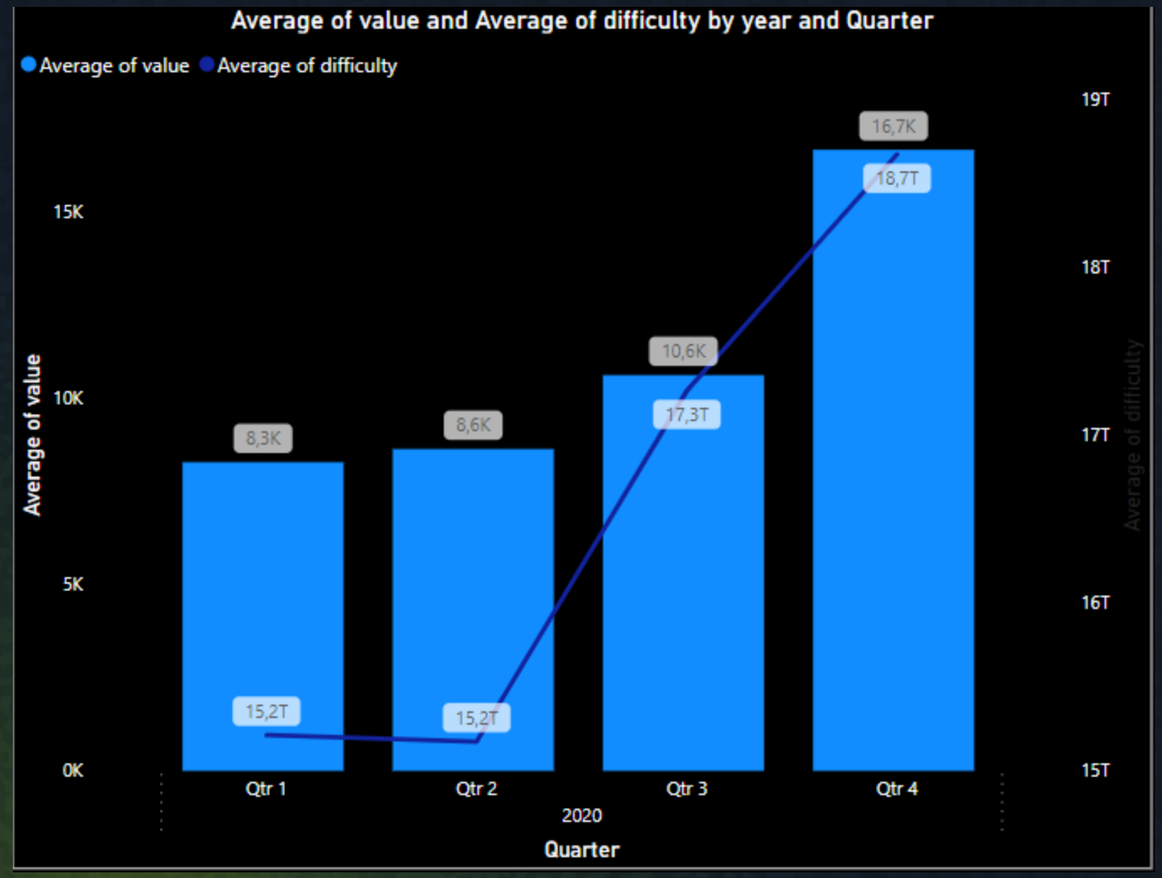
Distribution of Power Resources - Miners

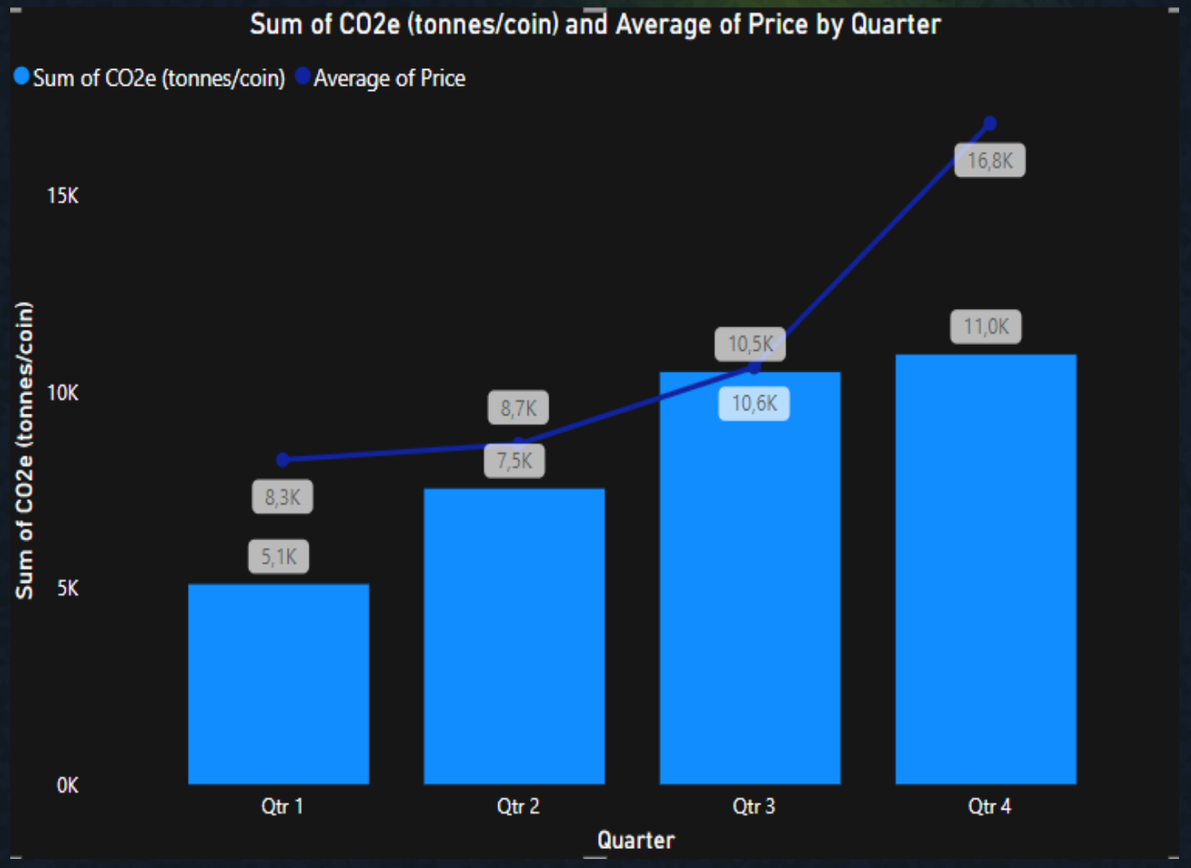




- Pennsylvania miners primarily rely on coal and natural gas for energy.
- Coal distribution is uniform across various miner locations.

Bitcoin Halving

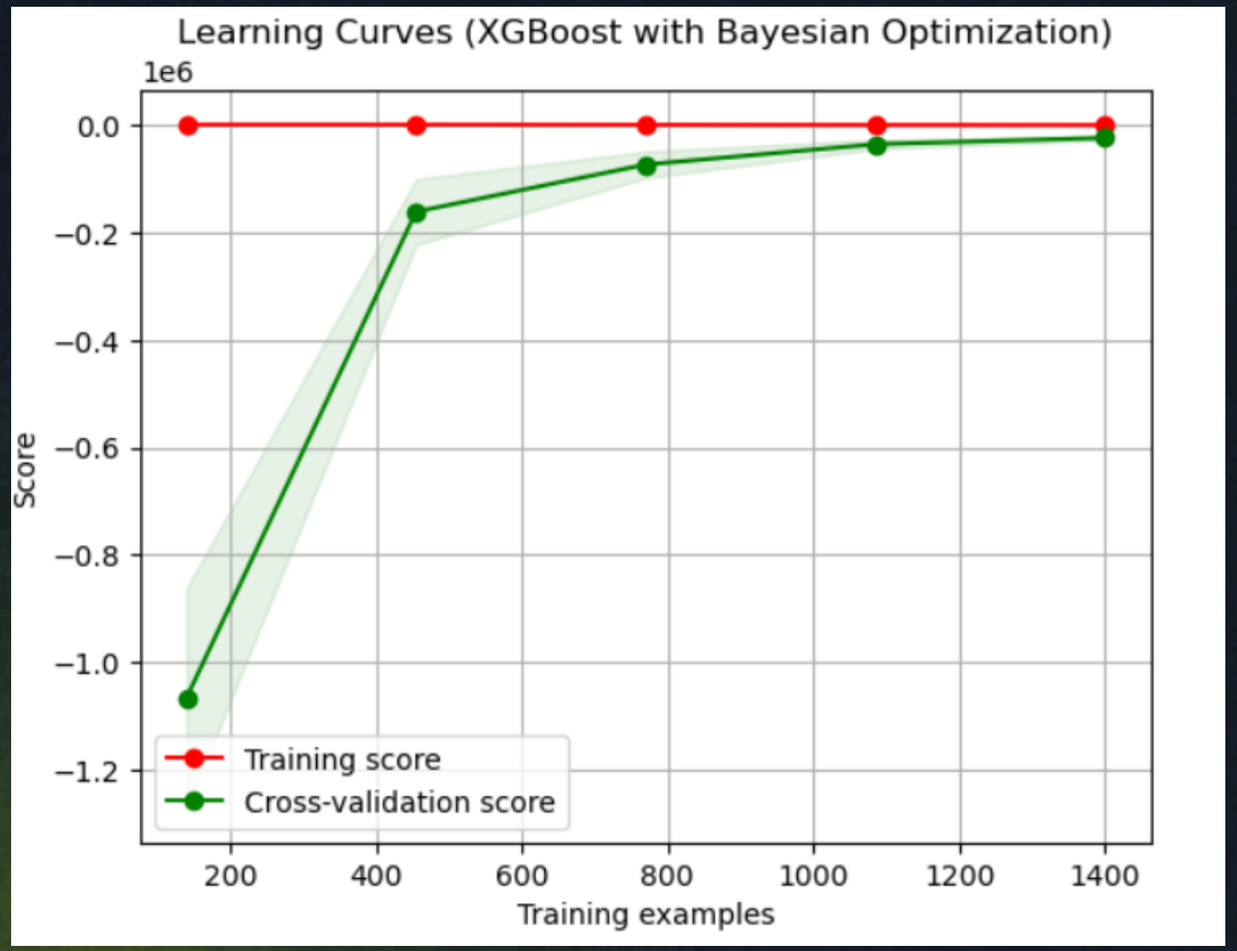


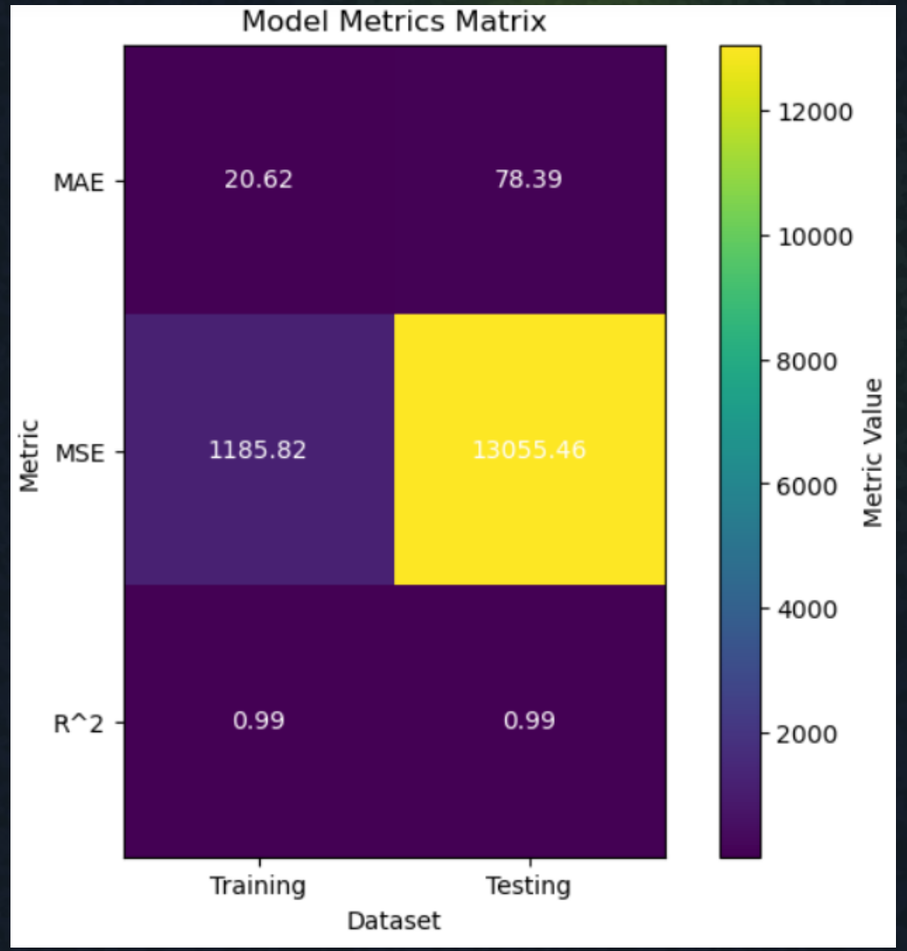


Statistical Modeling - Methodology

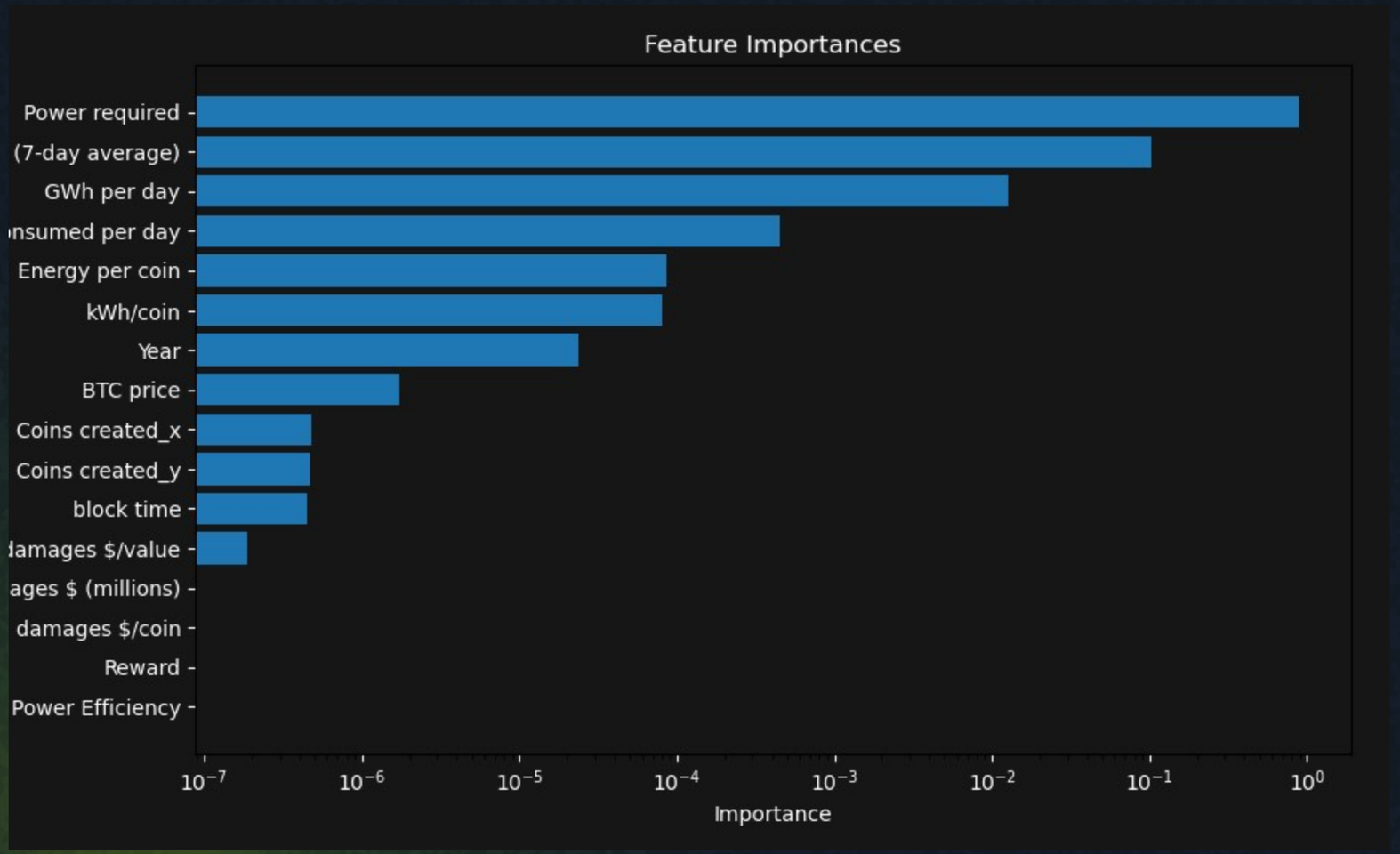
Data Processing	Feature Selection	Model Selection	Hyperparameter Tuning	Model Evaluation
Merged and Cleaned the Dataset to preprocess features.	Selected Features which are statistically significant for our model.	Used an XGB Regressor to predict our target Co2 Emissions based on our datapoints.	Selected the solution space using a Bayesian Optimization function for best parameters.	Evaluated the Model metrics and applied checks for overfitting.

Statistical Modeling – Cross-Validation & Metrics





Statistical Modeling – Feature Importance



- The graph reveals that the most important features are the power required to mine Bitcoin and the energy consumed per day by the Bitcoin network.

- These features indicate the environmental impact of Bitcoin, which is a major concern for many people.

- The graph also shows that the price of Bitcoin, the number of coins created, and the block time are relatively less important features.

- These features reflect the market dynamics and the technical aspects of Bitcoin.

- The graph suggests that the energy efficiency of Bitcoin is the least important feature, meaning that it does not have a significant influence on the performance or value of Bitcoin.

Our Findings

There exists a moderately positive correlation between Bitcoin prices and CO2 emissions from mining activities, indicating that changes in Bitcoin prices tend to coincide with changes in CO2 emissions.

The relationship between Bitcoin prices and CO2 emissions is influenced by various factors, including technological advancements, regulatory developments, and market dynamics.

While CO2 emissions from Bitcoin mining contribute to environmental concerns, the extent of their impact on Bitcoin prices is subject to other factors that shape cryptocurrency markets.

The findings underscore the importance of addressing the environmental impact of cryptocurrency mining through sustainable practices and regulatory interventions.

Suggestions

Address Concern

- Our analysis suggests that cryptocurrency institutions should address the environmental impact of mining.

Financial Brands

- As major financial brands venture into crypto, they must recognize both financial risks and environmental responsibilities.

Green Solutions

- Bitcoin mining can adopt renewable energy, alongside repurposing waste energy.
- Embracing renewable electricity promotes a more socially responsible approach to cryptocurrency operations.

Conclusion

- Our model underscores the pivotal role of network hashrate and power consumption as primary drivers influencing CO_2 emissions, shedding light on key factors shaping the environmental impact of cryptocurrency mining.

- Urgent measures are needed to address the significant environmental impact of Bitcoin mining, which is responsible for substantial CO_2 emissions annually, largely fueled by energy-intensive processes reliant on fossil fuels.

- The comparative analysis reveals that Bitcoin's environmental toll, in relation to its market value, mirrors that of traditional gold mining, highlighting the pressing need for sustainable practices and regulatory interventions within the cryptocurrency industry.

Reference

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