Filecoin Energy Consumption

Analyzing energy and storage data and explore correlations with $FIL token price

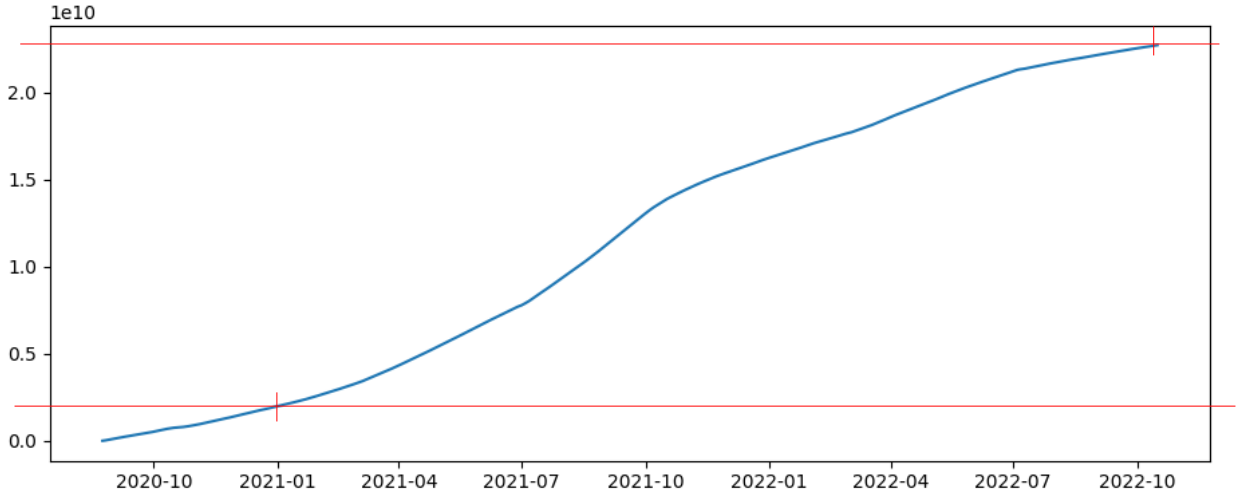
December 2022

1. Global Analysis

(Note: Filecoin provides upper band, estimate bound and lower bound figures for their energy consumption data. Unless otherwise specified, the estimate bound figures have been used to perform the tasks outlined in this challenge)

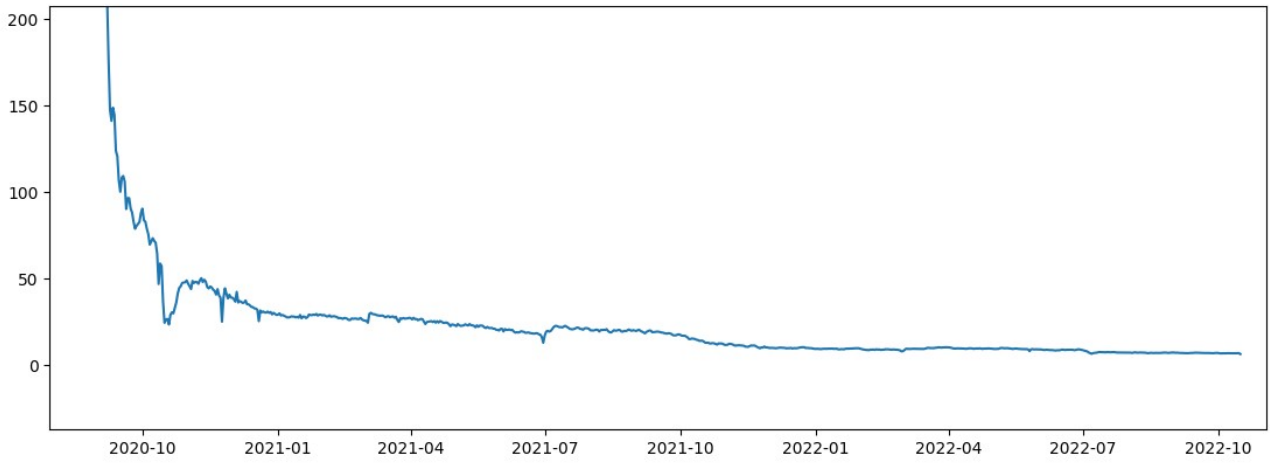
1.1 Analyze the energy performance and the evolution of Filecoin's storage

In the past two-and-a-half years, Filcoin's storage capacity has increased significantly. From less than 2 Exbibytes (EiB) by the end of 2022 to more than 22 EiB bij mid-October 2022, roughly a tenfold increase within the mentioned timeframe.



Filecoin Storage capacity (in Gb)

Whilst energy consumption has increased also during this timeframe, it did not nearly increase in the same pace. Energy consumption rates went up from around 3000-5000MW in the last quarter of 2020 to around 14000-15000MW in last quarter of 2022. So when the storage capacity increased tenfold, the energy consumption only increased 3-5 times. In other words, Filecoin has become much more energy efficient than two years ago. This is also demonstrated by the Energy Intensity figures, defined as the power usage (in MW) per ExbiByte (EiB) of storage.



Energy Intensity (MW/EiB)

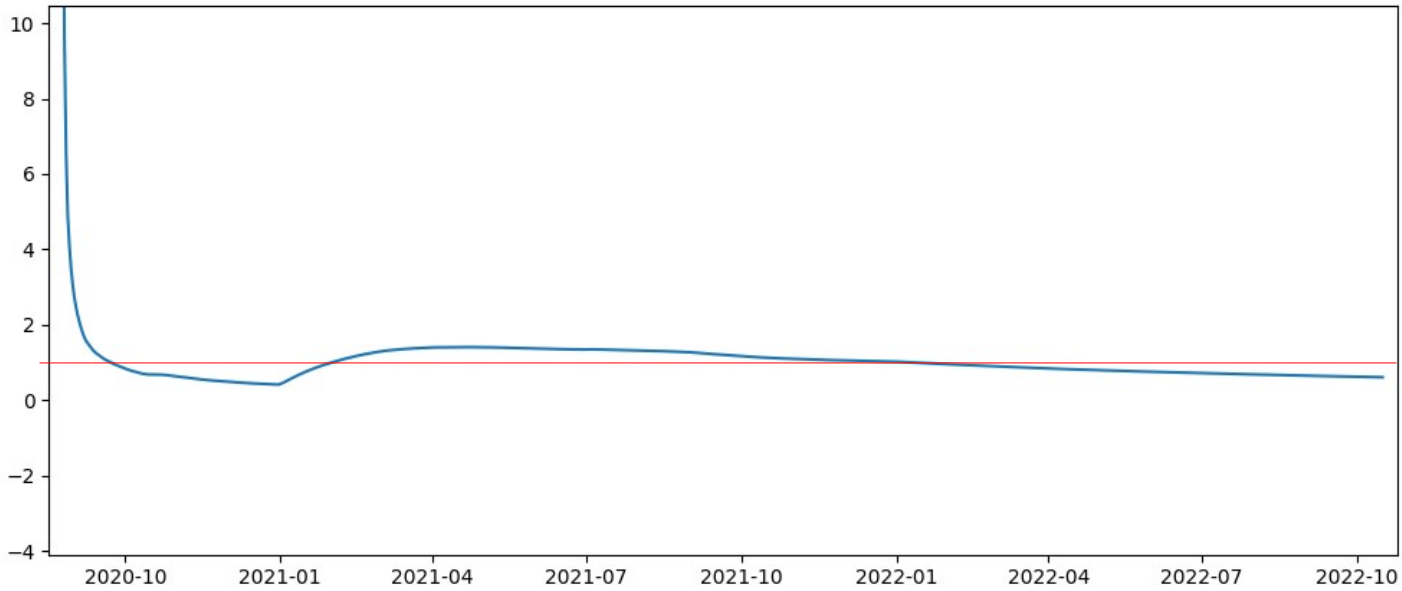
The data does not provide sufficient evidence to pinpoint the reasons for this, but it possibly is at least in part the result of the positive impact of scale at Filecoin storage providers (overhead power consumption can be divided across more storage capacity) and the utilization of new(er) and more energy-efficient technologies (SSD vs HDD).

1.2 Analyze the evolution of the share of renewable energy used by Filecoin

The renewable energy share has been defined as the ratio between the cumulative renewable energy purchases and the cumultative energy use estimate.

df_energy["Renewable energy share"]=df_energy["Cumulative renewable energy purchases"] / df_energy["Cumulative energy use estimate"]

Based on the data provided (and not taking into account the early outliers), the renewable energy share started increasing from January 2021 towards figures higher than 100% (effectively more than compensating the full energy consumption until then), but around start of 2022 it started to drop towards a share of around 60% of the total energy consumption to date.



Renewable energy purchases share

```
>>> print(df_energy[["Date","Renewable energy share"]].tail(30))
                         Date  Renewable energy share
754 2022-09-17 00:00:00+00:00                0.631309
755 2022-09-18 00:00:00+00:00                0.630348
756 2022-09-19 00:00:00+00:00                0.629386
757 2022-09-20 00:00:00+00:00                0.628439
758 2022-09-21 00:00:00+00:00                0.627496
759 2022-09-22 00:00:00+00:00                0.626563
760 2022-09-23 00:00:00+00:00                0.625625
761 2022-09-24 00:00:00+00:00                0.624686
762 2022-09-25 00:00:00+00:00                0.623752
763 2022-09-26 00:00:00+00:00                0.622827
764 2022-09-27 00:00:00+00:00                0.621914
765 2022-09-28 00:00:00+00:00                0.621000
766 2022-09-29 00:00:00+00:00                0.620074
767 2022-09-30 00:00:00+00:00                0.619152
768 2022-10-01 00:00:00+00:00                0.618228
769 2022-10-02 00:00:00+00:00                0.617337
770 2022-10-03 00:00:00+00:00                0.616453
771 2022-10-04 00:00:00+00:00                0.615559
772 2022-10-05 00:00:00+00:00                0.614667
773 2022-10-06 00:00:00+00:00                0.613786
774 2022-10-07 00:00:00+00:00                0.612894
775 2022-10-08 00:00:00+00:00                0.612008
776 2022-10-09 00:00:00+00:00                0.611118
777 2022-10-10 00:00:00+00:00                0.610235
778 2022-10-11 00:00:00+00:00                0.609359
779 2022-10-12 00:00:00+00:00                0.608480
780 2022-10-13 00:00:00+00:00                0.607595
781 2022-10-14 00:00:00+00:00                0.606715
782 2022-10-15 00:00:00+00:00                0.605838
783 2022-10-16 00:00:00+00:00                0.605031
```

2. Correlation

2.1 Correlation between energy used to seal Filecoin data and $FIL price

For determining the correlation between the energy used to seal Filecoin data and the $FIL price, the correlation function in panda was used:

```
>>> print(df_energy_price['Energy used to seal data estimate'].corr(df_energy_price['Close']))
0.5836671865903874
```

A moderate positive correlation can be concluded based on this.

2.2 Correlation between daily added storage capacity and $FIL price

For determining the correlation between the capacity of storage added per day in the Filecoin network and the $FIL price, the correlation function in panda was used:

```
>>> print(df_energy_price['Data storage capacity added per day'].corr(df_energy_price['Close']))
0.5836671865917777
```

An equally moderate positive correlation can be concluded based on this.

2.3 Correlation between the energy consumption rate and $FIL price

For determining the correlation between the energy consumption rate of the Filecoin network and the $FIL price, the correlation function in panda was used:

```
>>> print(df_energy_price['Energy consumption rate estimate'].corr(df_energy_price['Close']))
0.0836577617148742
```

A negligible correlation can be concluded based on this.

2.4 Observations

Based on these correlations, a moderate positive correlation is found for daily added storage and energy used in the sealing process in relation the $FIL price. Both these data elements are linked to the introduction of new storage capacity in the Filecoin network. The total energy consumption rate does not correlate with the $FIL price. An observation could therefore be that adding new storage capacity has a positive impact on the $FIL price (and/or vice-versa), but ‘simply’ keeping the storage capacity unchanged does not lead to an impact on the $FIL price.

3. Predict daily increase in data storage

Apologies, I have to further educate myself in understanding and working with predictive models before being able to address this element of the challenge and did not have sufficient time to get this working. My approach was to start with applying an LSTM model on the daily added storage data provided to develop a prediction for the daily increases in the near future.

Appendix - Approach

- Setup a new polygon wallet address using Account.create() in python
- Setup ocean environment in python to obtain two required files from the Ocean Market:

```
from ocean_lib.web3_internal.utils import connect_to_network
connect_to_network("polygon")
import os
from ocean_lib.example_config import get_config_dict
from ocean_lib.ocean.ocean import Ocean
config = get_config_dict("polygon")
ocean = Ocean(config)
challenge_private_key=<private key>
challenge_wallet = accounts.add(challenge_private_key)
assert accounts.at(challenge_wallet.address).balance() > 0, "Wallet needs MATIC"
filecoin_energy =
ocean.assets.download_file("did:op:7b993720ab80ef3139670b42564d6272c2584fff6fa625c671a1750e90209290",challenge_wallet)
filecoin_price =
ocean.assets.download_file("did:op:d2f9630759d2fad32d1765a5e9a380b77e674a9561d107a062bd47a66b70f4bc",challenge_wallet)
```

- Note that downloading the files this way did not work and resulted in an error. When requesting support on this in Discord, it became clear there was an issue related to downloading free files:

- Next, use panda DataFrames to read csv files and utilize panda DataFrames for further processing and analysis.