

Electricity and Bitcoin: Mining Profitability Analysis

Optimal Mining Hours and Trends in the Western Texas Load Zone

A Comprehensive Study on Electricity Prices and Mining Patterns

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Purpose

This report aims to identify optimal mining hours for Bitcoin operations based on electricity price patterns in the Western Texas Load Zone. Given the high volatility of ERCOT's energy-only market, this analysis provides actionable insights into profitable mining periods by comparing hourly and quarter-hourly electricity prices against breakeven margins over three time frames: Year-to-Date, Last 6 Months of 2024, and Last 1 Month of 2024. The findings equip miners and operators with data-driven strategies to maximize profitability in a highly volatile market

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Introduction

The profitability of Bitcoin mining is closely tied to electricity prices, which represent the largest operational cost. In Texas, electricity prices are governed by ERCOT (Electric Reliability Council of Texas), which operates an independent energy-only market, making it unique compared to the national grid's capacity market.

The Real-Time Pricing system employed by ERCOT, coupled with a reliance on diverse power sources like natural gas, wind, solar, coal, and nuclear, makes electricity prices highly volatile. For example, in 2024, electricity prices in the Western Texas Load Zone ranged from -\$31.87/kWh to \$4,981.33/kWh, with a mean of \$36.23/kWh. Identifying patterns in these volatile prices is critical for profitable mining operations.

This report analyzes quarter-hourly electricity prices from ERCOT and compares them against Bitcoin's breakeven price margins over three timeframes. By leveraging extensive datasets and visualization tools like PostgreSQL and Tableau, the study provides actionable insights into the most effective and profitable mining periods.

Through this analysis, miners can navigate the complexities of a volatile market with greater confidence, optimize operations, and minimize losses during challenging periods.

Methodology

This analysis was conducted using a systematic approach to ensure accuracy and integrity, the following steps outline the key processes and tools employed:

Data Collection

1. Electricity Prices
 - a. Real-Time Yearly Electricity Price data was obtained from the ERCOT Archive of Historical Real-Time Model Load Zone and Hub Prices.
 - b. The data covered all 15-minute intervals across 2024, approximately 2,900 records each month.
2. Bitcoin Prices
 - a. Historical Price Data was obtained from CoinMarketCap
 - b. The prices were recorded as daily averages. Basic Data Manipulation was later employed to calculate the average Bitcoin price for the whole of 2024, the last 6 months of 2024 and the last 1 month of 2024.

Data Cleaning and Preparation

1. Google Sheets
 - a. Initial Data Filtering: Filters were utilized to extract only the data that was required for this analysis.
 - b. Preparation for SQL: Filtered Data was inspected and formatted to meet the standards of PostgreSQL to ensure accurate calculations and visualizations later on.
2. PostgreSQL
 - a. Timestamp: Due to the unusual nature of the time format of ERCOT's price data, new Timestamps had to be created to successfully connect the data server to Tableau.
 - b. Aggregation: Aggregated hourly interval prices from approximately 35,000 rows of data to calculate the data needed for Monthly and Yearly average charts.
 - c. Frequency Count: Frequency Count table was created to generate a visualization that accompanies the Monthly and Yearly average charts.

Breakeven Price Calculation

1. The Breakeven Price for Electricity for Bitcoin Mining was calculated individually for the 4 Miner models and the two mining modes each Miner has which are Normal Power Mode and Low Power Mode resulting in 8 Breakeven Prices for Electricity.
 - a.
$$\text{Breakeven Price(USD/kWh)} = ((\text{Miner Hashrate (TH/s)}/\text{Network Hashrate(TH/s)}) \times \text{Block Reward(BTC)} \times \text{Bitcoin Price(USD)} \times 144) / (\text{Power Usage(W)}/1000) \times 24$$

2. The Electricity prices across 2024 had a Standard Deviation of \$76.04/kWh while the 8 Breakeven Price values had a Standard Deviation of ~\$0.04/kWh. For that reason, the average of the 8 Breakeven Price values to calculate the final Breakeven Price values for the 3 timeframes(Year-to-Date, Last 6 months, Last 1 month).

Visualization and Analysis

1. Tools
 - a. Tableau was used to create visualizations including line graphs, area graphs and frequency plots.
 - b. PostgreSQL was used for queries and aggregations for deeper insights.
2. Visualizations
 - a. Quarter-hourly values were compared against a Breakeven Price reference line.
 - b. Frequency graphs highlighted the most profitable mining hours by showing the occurrence of below-breakeven prices in Monthly and Yearly periods.

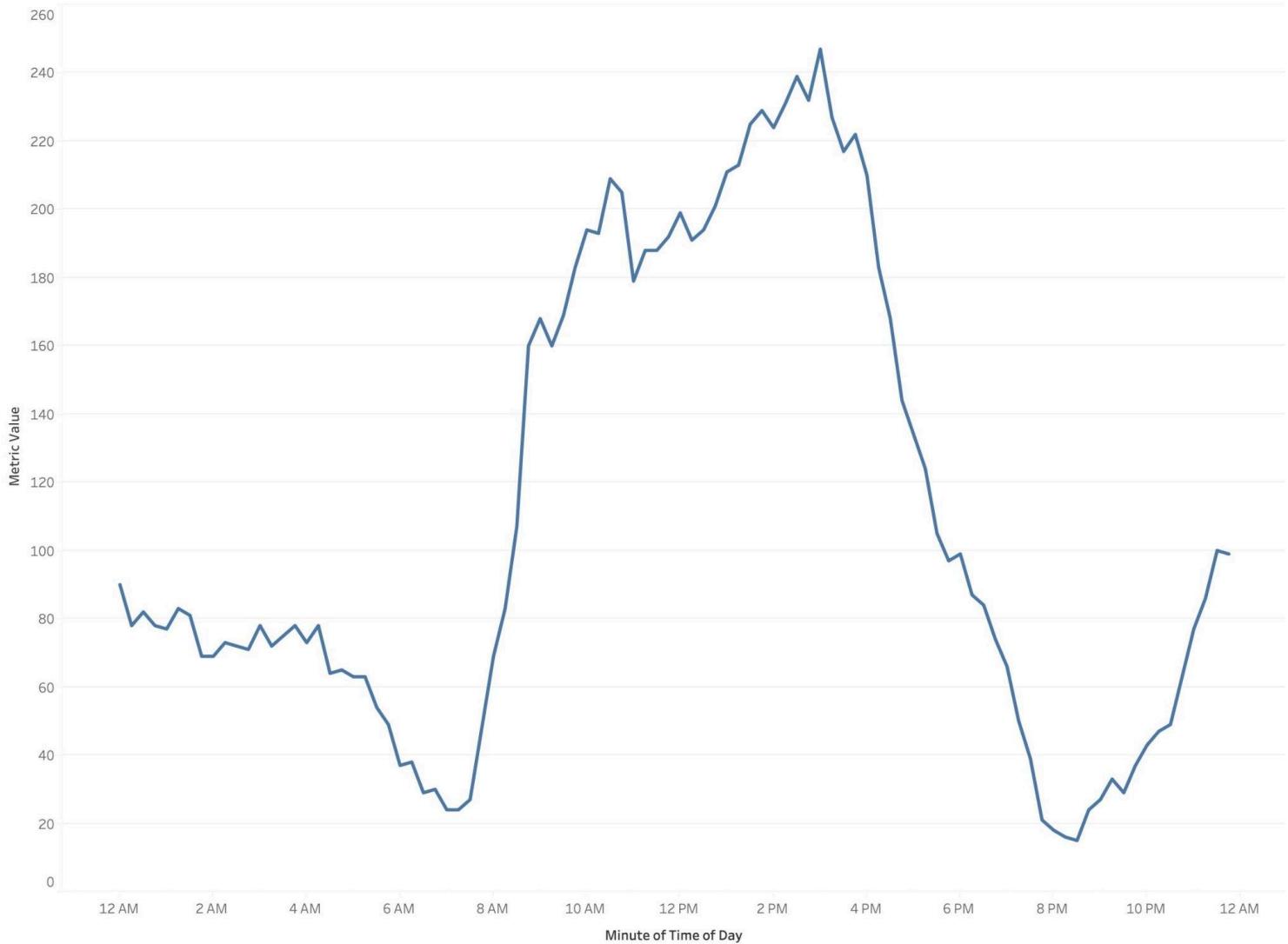
Limitations

1. This analysis excludes external factors such as cooling costs, regulatory impacts, miner maintenance and other operating costs.
2. It assumes constant mining efficiency and does not account for dynamic operational adjustments.

By leveraging a combination of robust data sources, effective cleaning techniques, and advanced visualization tools, this methodology ensures a comprehensive and actionable analysis of mining profitability in a volatile electricity market.

Comprehensive Report: 2024 Electricity and Mining Trends

Yearly Total



The goal is to provide a clear understanding of daily trends and pinpoint the most profitable mining hours within a 24-hour period.

Key Insights:

Early Morning(12AM-6AM):

- Trend: Throughout the whole year, the day generally started off moderately strong, at about 95 before slowly plateauing to ~30.
- Profitability: This period shows early mining opportunities but the general downward trend indicates that these hours are not the most profitable.
- Profitability Rate: 6.62%

Morning Peak(6AM - 12PM):

- Trend: Strong upward trends picked up at 7AM after hitting a low of ~25 as part of the dawn decline. With sharp momentum, figures skyrocket to 210 before slightly dipping back to 190.
- Profitability: This time frame allows for lucrative mining, offering a positive and steady growth in below breakeven electricity price frequencies.
- Profitability Rate: 11.08%

Afternoon Decline(12PM - 6PM):

- Trend: After a steady growth from 190 to 250 in a 3-hour period, a steep decline sees figures fall from a daily high of 250 to 90.
- Profitability: This period indicates profitable mining opportunities earlier on but as time passes, those opportunities rapidly diminish.
- Profitability Rate: 17.81%, despite the harsh decline in figures, it is by far the most profitable period for mining.

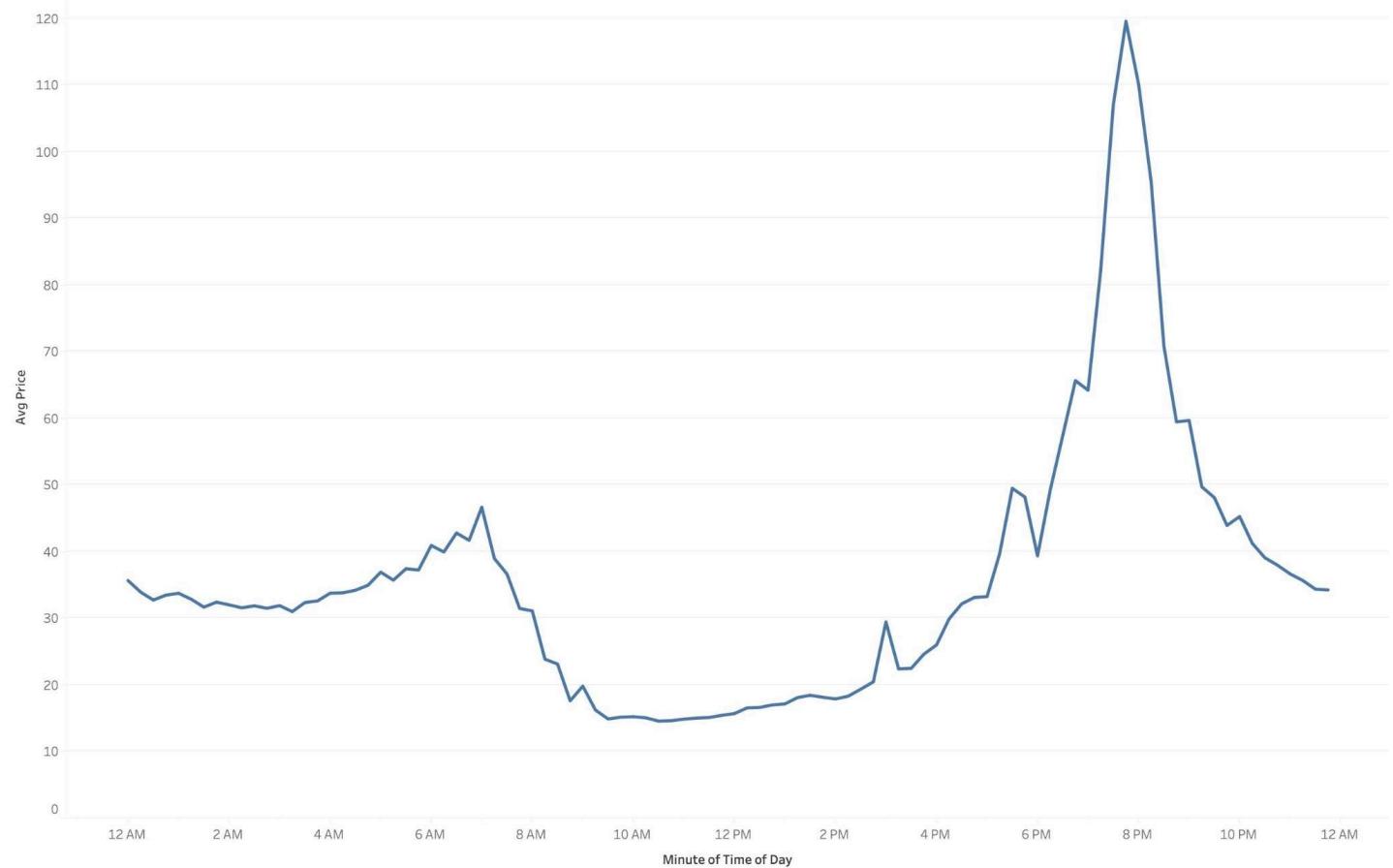
Nighttime Recovery(6PM-12AM):

- Trend: The intense decline that started at 3PM bottoms out at ~18 at 8PM followed by a gradual increase all the way to 100 at 12AM.
- Profitability: This timeframe presents some late night mining opportunities past 8PM, while not the most lucrative, it is still a decent off-peak mining opportunity.
- Profitability Rate: 4.9%, the least lucrative period, mainly as a result of the intense decline at the start.

Implications and Recommendations:

- Moderately profitable early morning hours(12AM - 5AM):
 - While nowhere near the figures later in the day, this period offers a fair frequency of below breakeven electricity prices.
- Focus on the Mid-day hours(9AM - 6PM):
 - After a decline in the early morning, the figures start to pick up steadily for 7 hours, presenting the best and most profitable opportunity for mining.

Yearly AVG



*Lower the Y, higher the profitability

Figure 0.2 Yearly Average Electricity per kWh

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis further illustrates and highlights the most profitable hours for mining in a 24-hour period based on the average price per kWh across 2024, doubling down on the insights gained from the “Yearly Below Breakeven Electricity Price Frequency” Chart.

- X-axis: Time of Day in 15-minute intervals
- Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Key Insights:

12AM - 6AM:

- During the early morning hours, prices are steady, hovering between \$32/kWh and \$36/kWh.
- Some opportunities to mine during small periods of price drops but generally a gray area for mining.

6AM - 12PM:

- Prices start to gradually fall starting 7AM at the \$45/kWh mark. This decrease in electricity price bottoms out at 9:30AM and evening out at approximately \$16/kWh hitting the lowest prices for the day.
- This period is by far the most optimal for mining, offering the lowest and most stable prices.

12PM-6PM:

- Figures start off on the stable side of things, remaining stagnant around \$18/kWh before prices rapidly rise and hit a mid-day high of \$50/kWh.
- Following the trend of stable low prices from morning, the first half of this period allows for optimal mining while the second half of the period sees prices hike towards a daily high later in the evening.

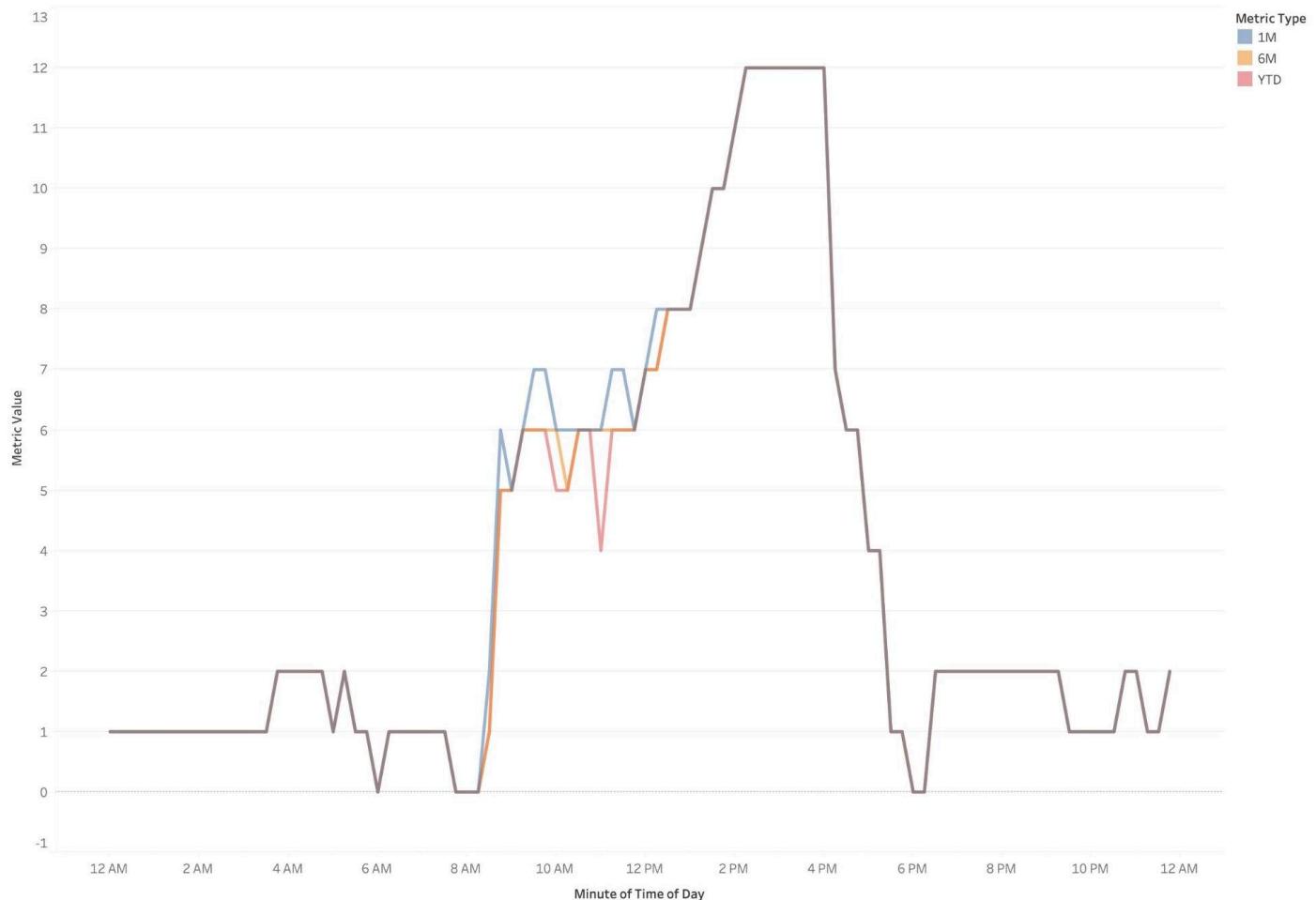
6PM-12PM:

- The upward trend that started at 3PM makes its way well into the end of the day, skyrocketing to \$120/kWh before halving to \$60/kWh by 9PM with the same momentum. Past 9PM, prices are still on the decrease but not as rapidly, heading towards a low of \$35/kWh by 12AM.

Implications and Recommendations:

- Start the day off strong:
 - Morning hours(12AM-6AM) offer moderate mining opportunities earlier on in the day.
- Low and Stable prices:
 - Mid day hours between 8:45AM and 2:45PM consistently offer the lowest prices for the day. The average price for this period in 2024 was \$16.71/kWh, further indicating that this was the best mining period.

January Report: Electricity and Mining Trends

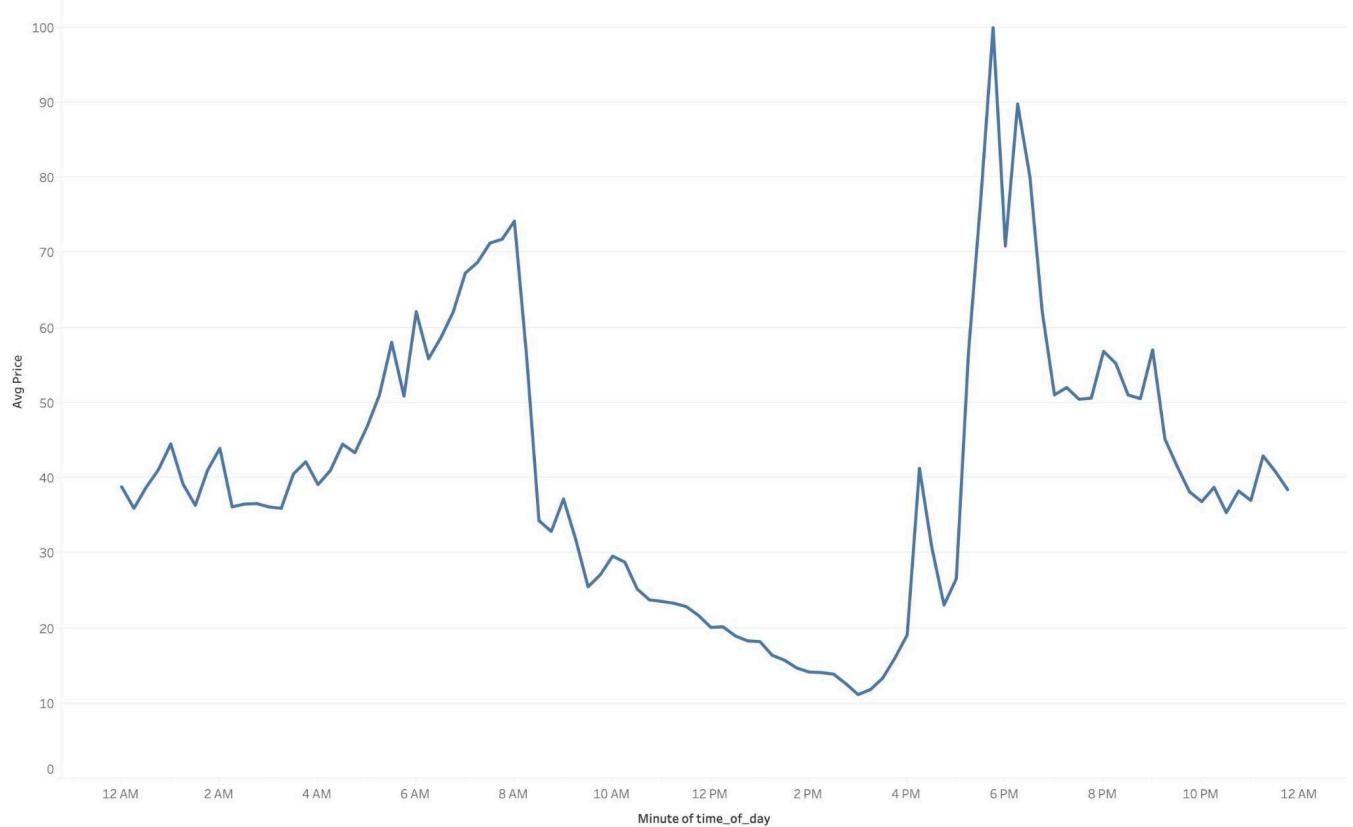


*Higher the Y, higher the profitability

Figure 1.1 Monthly Below Breakeven Electricity Price Frequency: January

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 1.2 Monthly Average Electricity per kWh: January

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-breakeven electricity prices and the average price per kWh across a 24-hour period in January of 2024.

Key Insights:

12AM - 6AM:

- Things start off slow for the day, average prices per kWh are fairly stable at \$40/kWh but that figure is nowhere near the amount needed to get into the positive profit margins.
- Profitability Rate: 4.03%

6AM - 12PM:

- Prices start to hike up as part of an early morning upward trend before dropping drastically from \$74/kWh to \$33/kWh in a matter of minutes around 8AM. After 8AM, there is still a gradual drop in prices, presenting moderate mining opportunities.
- Profitability Rate: 11.08%

12PM - 6PM:

- Below Breakeven Price frequencies start off at 6 at 12PM and quickly doubles to 12 by 2PM, remaining there until 4PM before plummeting all the way down to 0 by 6PM. These rapid changes are also reflected in the average prices, as prices drop down to \$15/kWh around 2PM and bottoming out \$11/kWh by 3PM before slingshotting to a daily high of \$100/kWh at 6PM.
- Profitability Rate: 27.42%

6PM - 12AM:

- Following the daily high of \$100/kWh at 6PM, prices gradually back down to between \$45/kWh and \$55/kWh but these drops aren't significant enough to facilitate any profitable mining sessions.
- Profitability Rate: 4.90%

Implications and Findings:

- Mid-day boom:
 - Heavily focus on the 7-hour window between 9AM and 4PM. Frequency values truly only start to pick up at the beginning of this window before peaking 4PM and plummeting to 0 in the following hours. This trend is also heavily reflected in the average prices where the prices go from a daily-low to a daily-high in a matter of 2 hours.

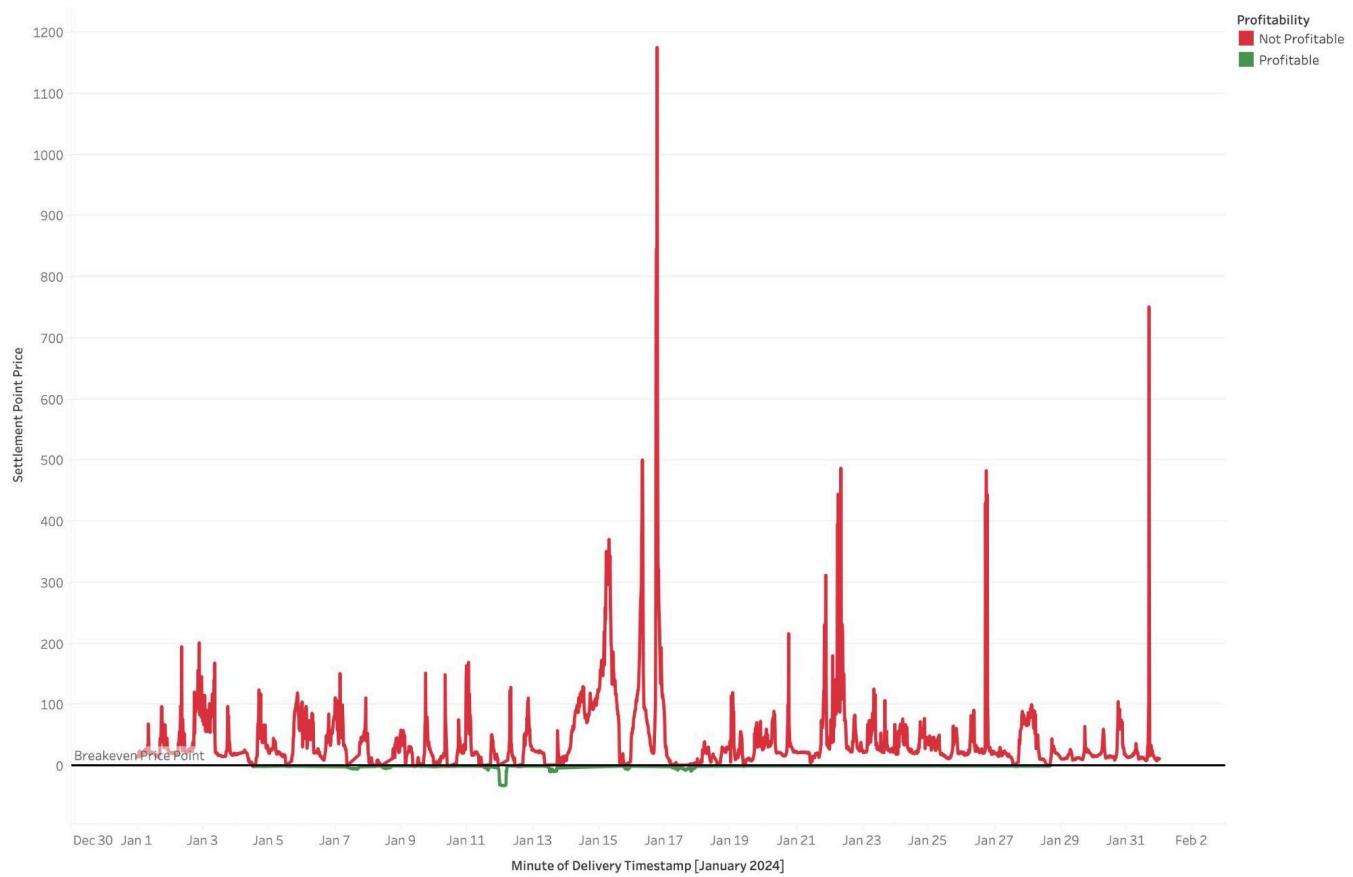


Figure 1.3 Monthly Profitability: January

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 1.3 above shows daily electricity prices for January 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

Profitability Rate: For January, mining was profitable 12.10% of the time, higher than the yearly average of 10.28%, indicating limited but fair opportunities compared to other months.

Trends:

- Mining opportunities were scarce during peak electricity price periods (e.g., January 15 – 17 and January 18 - 27).
- Most profitable windows occurred in the day hours between 9AM and 4PM and occasionally closer to midnight.

Conclusion: Despite the volatility in electricity prices, January showed consistent profitability during specific periods, particularly in mid-day sessions.

February Report: Electricity and Mining Trends

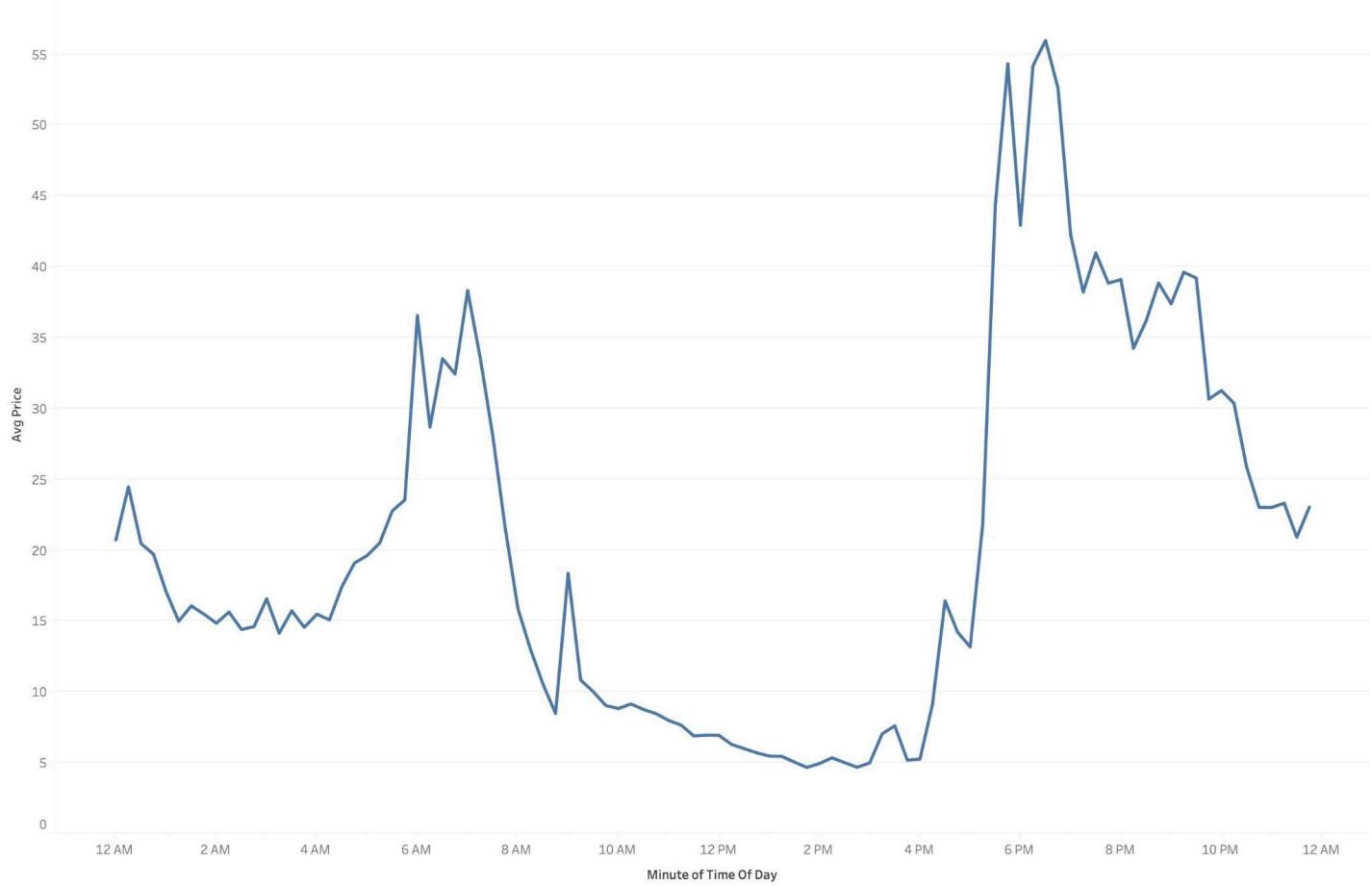


*Higher the Y, higher the profitability

Figure 2.1 Monthly Below Breakeven Electricity Price Frequency: February

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 2.2 Monthly Average Electricity per kWh: February

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-breakeven electricity prices and the average price per kWh across a 24-hour period in February of 2024.

Key Insights:

12AM - 6AM:

- Fairly average mining frequencies between 12AM and 1AM, figures are hovering steadily around 8 while prices slowly trickle down to \$15/kWh from a period high of \$25/kWh. \$15/kWh is the standard for a few hours until 5AM where prices pick up and reach \$23/kWh. Despite the stable prices for the most part, the actual frequency of below-breakeven prices started falling at 1AM, reaching a daily-low of 0 by 6AM.
- Profitability Rate: 14.51%

6AM - 12PM:

- Prices remain high between 6AM and 8AM, ranging between \$29/kWh and \$38/kWh. However, by 9AM, prices have dropped significantly, averaging out at \$8/kWh. This price drop is reflected in the frequency chart too as below-breakeven price frequencies jump from 0 at 8AM to 8 occurrences at 9AM. There is a slight hiccup at 10AM where the prices jump up to \$18/kWh but it's short lived as it drops down \$7/kWh.
- Profitability Rate: 14.80%

12PM - 6PM:

- Low prices continued into the afternoon, with averages dropping as low as \$5/kWh by 4PM and below-breakeven electricity prices hitting a day-high of 16. However, this trend reversed rapidly, prices increased more than tenfold, jumping from an average of \$5/kWh at 4PM to \$54/kWh by 6PM.
- Profitability Rate: 39.22%

6PM- 12PM:

- Late evening prices start off high, topping out at \$56/kWh by 7PM, luckily it's all downhill from there as it gradually falls down to \$23/kWh at 12AM. This drop is matched by the frequencies as it grows from a maximum of 2 in the previous hours to hitting 8 below-breakeven price occurrences for both 11PM and 12PM ending the day off strong.
- Profitability Rate: 9.20%

Implications and Suggestions:

- Off-peak Opportunities:
 - Starting 11PM until 2AM, there is a small window to get some conservative mining sessions accomplished.

- Catch the 9AM Wave:
 - Beginning right around 9AM, there is a strong general downhill trend in prices. Until 4PM, there are great chances to have some optimistic and aggressive mining underway. With the average price dropping as low as \$5/kWh between 1PM and 4PM, this is one of the lowest prices throughout the whole year.
- Rush hour Money pit:
 - The least optimal periods for mining in February of 2024 were between 6AM-7PM and 6PM-7PM aligning with Rush hour. Due to the overexertion of power reserves during these periods, prices are historically astronomically high and profitability during these hours are not feasible.

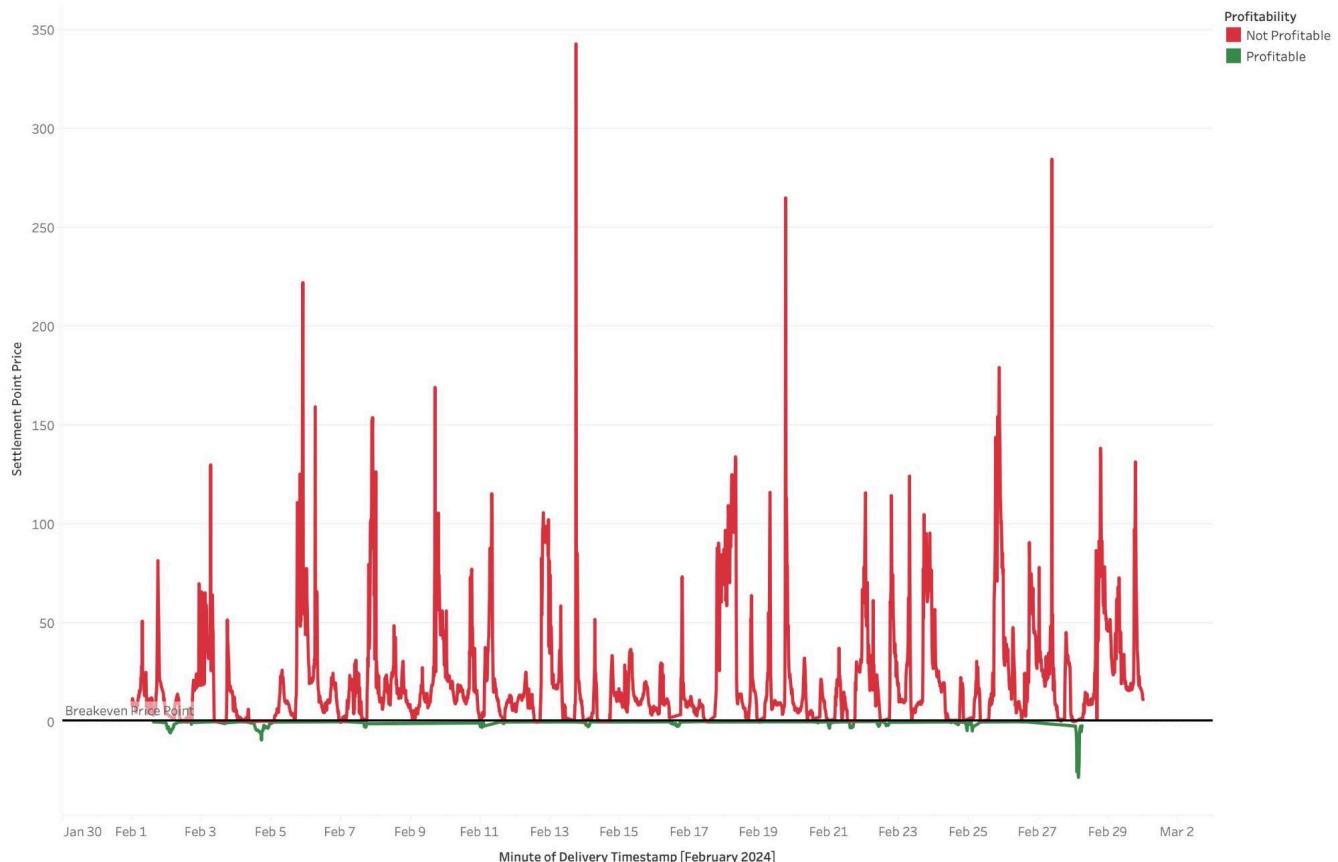


Figure 2.3 Monthly Profitability: February

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 2.3 above shows daily electricity prices for February 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

Profitability Rate: For February, mining was profitable 18.82% of the time, almost double the yearly average of 10.28%. With average prices bottoming out at \$5/kWh, the 9AM-4PM period was the primary driver of February's exceptional profitability.

Trends:

- Prices were quite volatile throughout the whole month but even then, there was a great abundance of below-breakeven electricity prices.

Conclusion: Regardless of the more than usual price volatility, February stood out as one of the best months for Bitcoin mining in 2024, thanks to low midday prices and consistent below-breakeven opportunities.

March Report: Electricity and Mining Trends

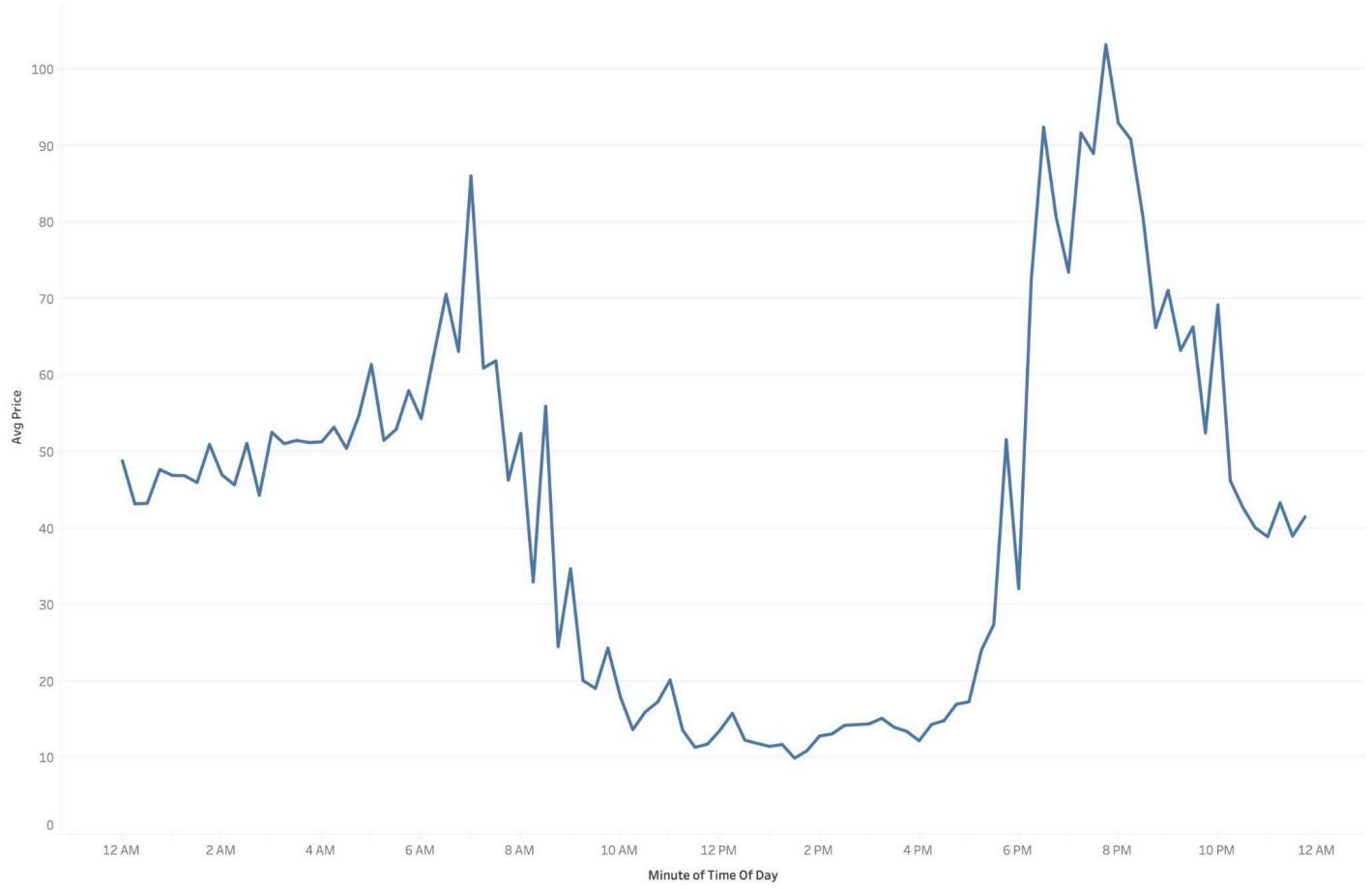


*Higher the Y, higher the profitability

Figure 3.1 Monthly Below Breakeven Electricity Price Frequency: March

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 3.2 Monthly Average Electricity per kWh: March

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-break-even electricity prices and the average price per kWh across a 24-hour period in March of 2024.

Key Insights:

12AM - 6AM:

- Kicking off the day on a positive note with frequencies at 8 despite higher average prices at \$49/kWh. Frequencies generally range between 5 and 8 from 12AM to 4AM. However, past 4AM, frequencies plunge down to 3 as the average prices slowly pick up, equaling \$55/kWh by 6AM.
- Profitability Rate: 16.26%

6AM - 12PM:

- Prices continue to rise as frequencies remain stagnant at 3. Beginning at 7AM, a rapid downward trend in prices gained momentum. Simultaneously, below-breakeven price frequencies exhibited solid positive growth.
- Profitability Rate: 11.69%

12PM - 6PM:

- The downward trend in prices has slowed down substantially and hover around \$12/kWh. On the other hand, below-breakeven prices frequencies are still going strong, hitting its peak of 14 at 3PM. Starting 5PM, profitability plateaus significantly as both figures head towards their daily-high and daily-low respectively.
- Profitability Rate: 32.80%

6PM - 12PM

- Profitable price frequencies keep going down until it bottoms at 7PM, but this trough is short-lived as prices rebound back up to 12 by 12PM. On the contrary, average electricity prices hit its apex of \$102/kWh at 8PM before a short but strong downward trend sweeps by and prices decline all the way down to \$41/kWh at 12PM.

Implications and Suggestions:

- Avoid the slumps:
 - Profitability is generally stable except for 2 periods, 4AM - 10AM and 6PM - 9PM. Mining during these periods won't yield much profits, therefore, it's best to focus on the remaining periods.
- Don't miss Lunch and Happy hour:
 - Between 11AM and 6PM, both graphs display consistent profitable figures. Especially in the second half of this period, there is a significant turnover of below-breakeven prices.

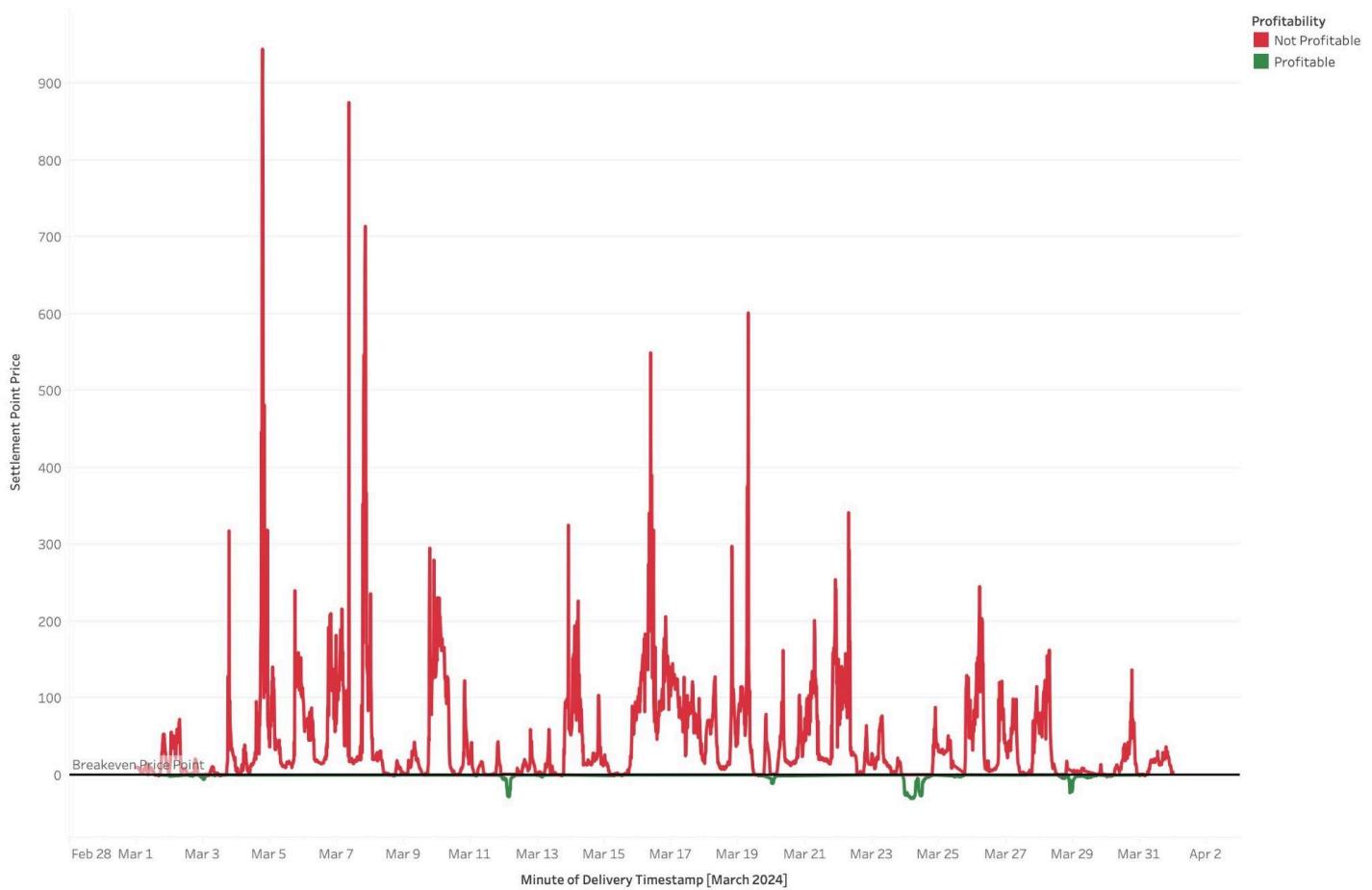


Figure 3.3 Monthly Profitability: March

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 3.3 above shows daily electricity prices for March 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

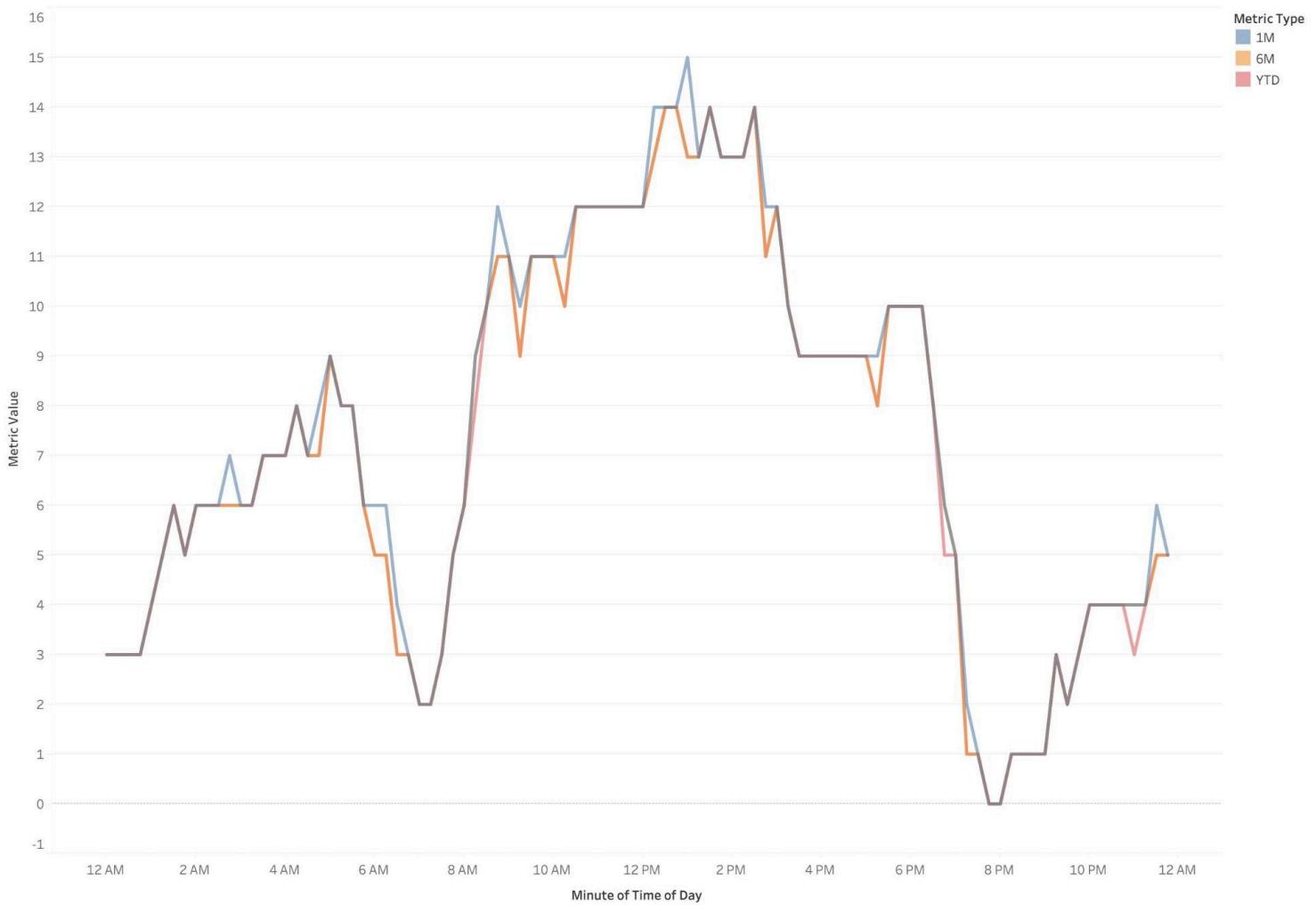
Profitability Rate: For March, mining was profitable 17.66% of the time, 71.8% more than the yearly average of 10.28%. Consistency was March's strong suit, with a Standard Deviation of 10.46% among the 4 6-hour periods, much lower than previous months'.

Trends:

- Prices skyrocketed past \$500/kWh on rare occasions and generally hovered around its average price of \$42.29/kWh.
- Overall, prices were relatively stable compared to previous months.

Conclusion: March, while not as profitable as its predecessor, still delivered consistent and positive figures throughout. March marks the start of the Spring Bonanza, a period characterized by increased profitability and stable prices in the months to follow.

April Report: Electricity and Mining Trends

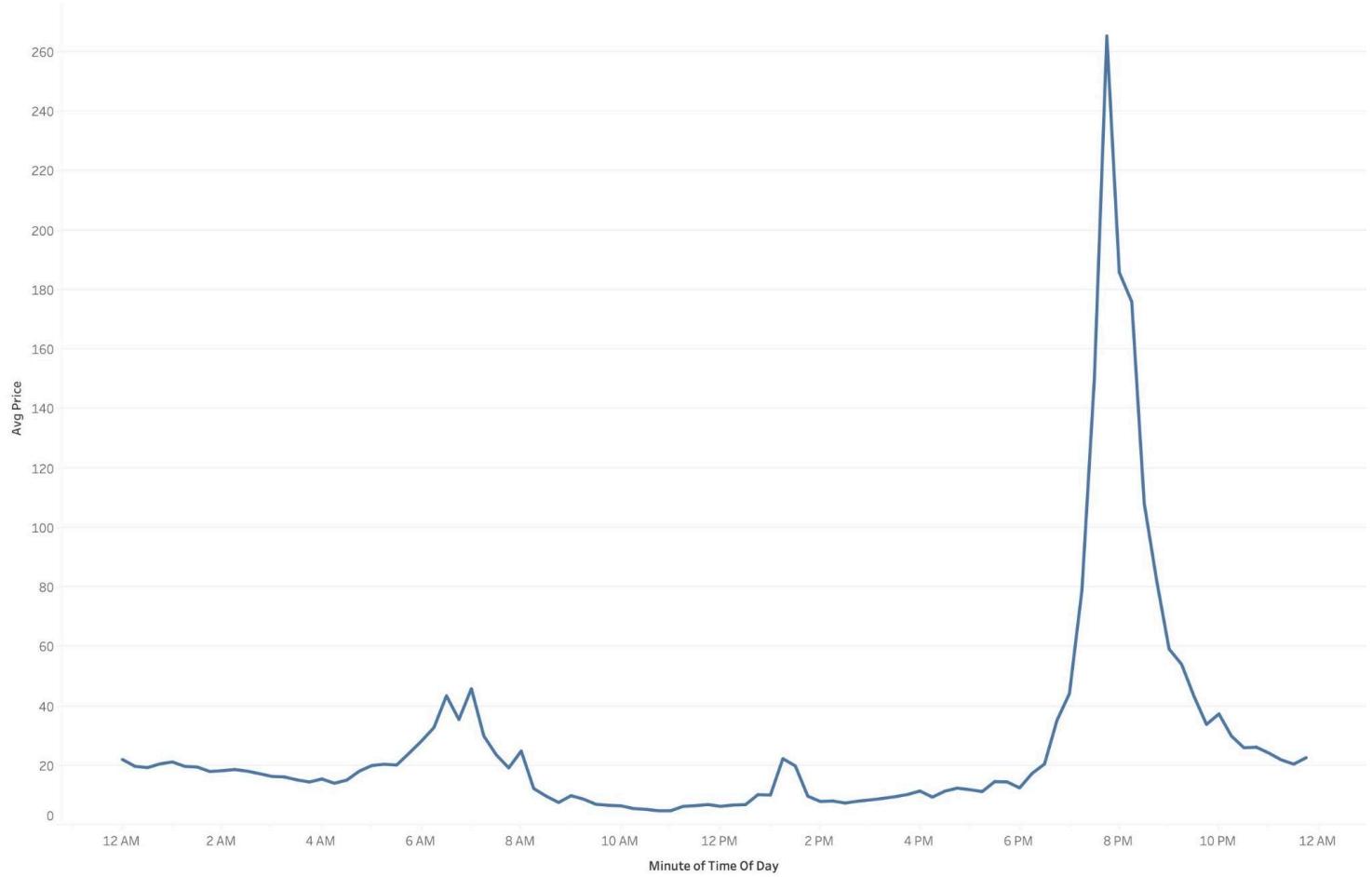


*Higher the Y, higher the profitability

Figure 4.1 Monthly Below Breakeven Electricity Price Frequency: April

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 4.2 Monthly Average Electricity per kWh: April

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-break-even electricity prices and the average price per kWh across a 24-hour period in April of 2024.

Key Insights:

12AM-6AM:

- It's relatively quiet at 12AM with frequency numbers at 3 and the average price at \$20/kWh. Although, it's not long before an upward trend starts in the below-breakeven price frequencies. Figures double at 2AM, reaching 6, on the other hand, there isn't much change in the average prices as they linger around the \$20/kWh mark. Frequencies rise all the way up to 9 by 5AM before plateauing to 3. This phenomenon can also be spotted in the average price as there is a slight upward curve bringing the average prices up to \$30/kWh at 6AM.
- Profitability Rate: 20%

6AM - 12PM:

- The plateauing frequencies make their way into the mid-morning where it bottoms out at 2 by 7AM. However, frequencies rebound, gaining momentum and hitting 12 at 11AM. Average prices reflect this momentum too as prices hit \$45/kWh at 7AM before dropping gradually and bottoming out at \$5/kWh.
- Profitability Rate: 28.47%

12PM - 6PM:

- The rebound from mid-morning is still going strong as it hits 15 below-breakeven price instances at 1PM. What's ironic is that this happened all while the average price jumped from a daily-low of \$5/kWh to \$22/kWh at 1PM. Following this, the prices drop back down and hover around the \$10/kWh mark. On the other hand, regardless of the cheaper average prices, frequencies fall to 10 at 6PM as quarter-hourly rates even out.
- Profitability Rate: 38.19%

6PM-12AM:

- Frequencies keep falling well into the last 6 hours of the day as the average prices spike to an astonishing \$265/kWh at 8PM resulting in 0 frequencies. On the plus side, prices fell as fast as it went up, hitting \$59/kWh at 9PM, \$30/kWh at 10PM before eventually reaching \$20/kWh at 12AM. A similar trend can be spotted in the frequency figures as it makes its way back up to 6 by 12AM.
- Profitability Rate: 12.36%

Implications and Suggestions:

- Capitalize on by far the most profitable month of the year:
 - A myriad of lucrative mining opportunities itself during April. Just the early morning hours of between 1AM and 6AM are more lucrative than some months will ever be. There is an even bigger window between 8AM and 6PM where average prices are well below \$9/kWh for the most part and frequencies being 9 at the least.
- Watch out sudden price surges:
 - While the general average price for April is stable, there are 2 periods where prices surge astronomically, 6AM - 8AM and 6PM - 9PM. The only mining to do during these periods is no mining as rush hour prices increase more than 20-fold in a matter of a few hours.

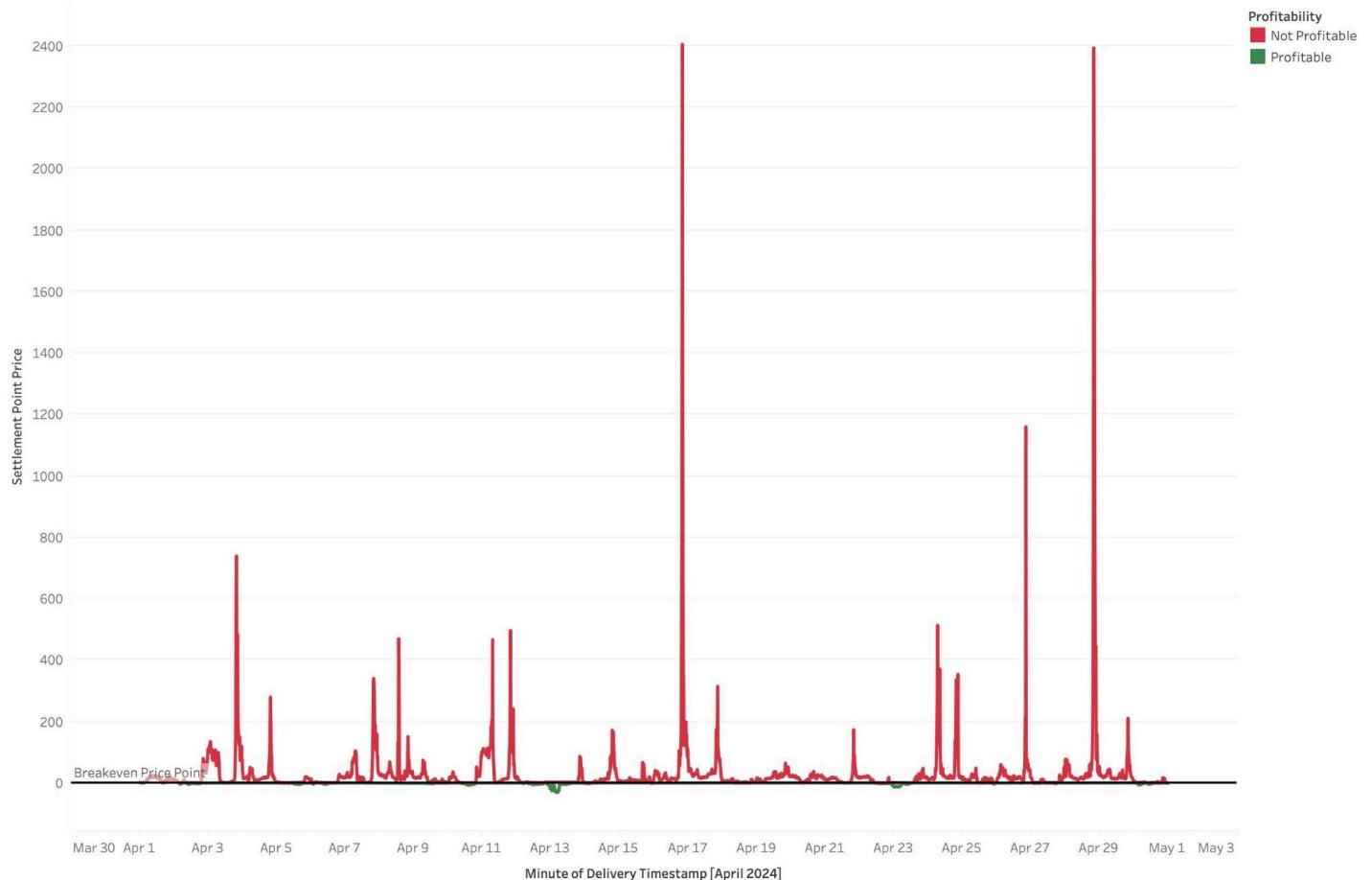


Figure 4.3 Monthly Profitability: April

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 4.3 above shows daily electricity prices for April 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

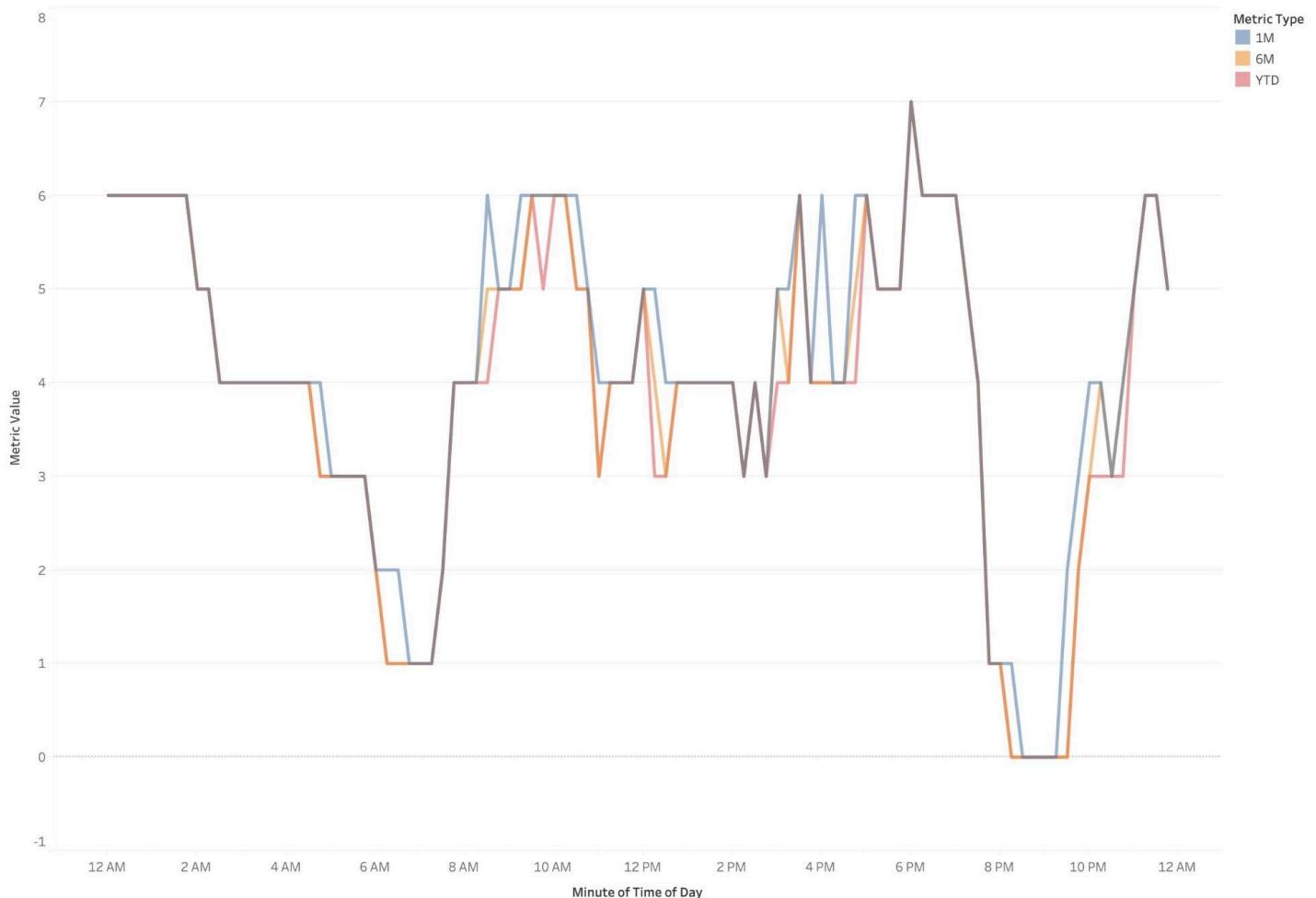
Profitability Rate: For April, mining was profitable 24.76% of the time, more than double the yearly average of 10.28%. This cements April as the most profitable month in 2024 as the coming months don't even break the 15% barrier.

Trends:

- Besides a few instances of ridiculously high prices such as \$2405/kWh, April was very profitable with 23 hours of the day always being profitable at some point throughout the month.
- The Average Price for April was \$27.78/kWh, on the other hand, the Median was only \$11.98/kWh. This puts it only behind February for both the lowest Mean and Median price.

Conclusion: April was the highlight of both the whole year and the Spring Bonanza as it delivered unrepeatable figures. Miners should heavily focus and giddy-up ahead of this month.

May Report: Electricity and Mining Trends

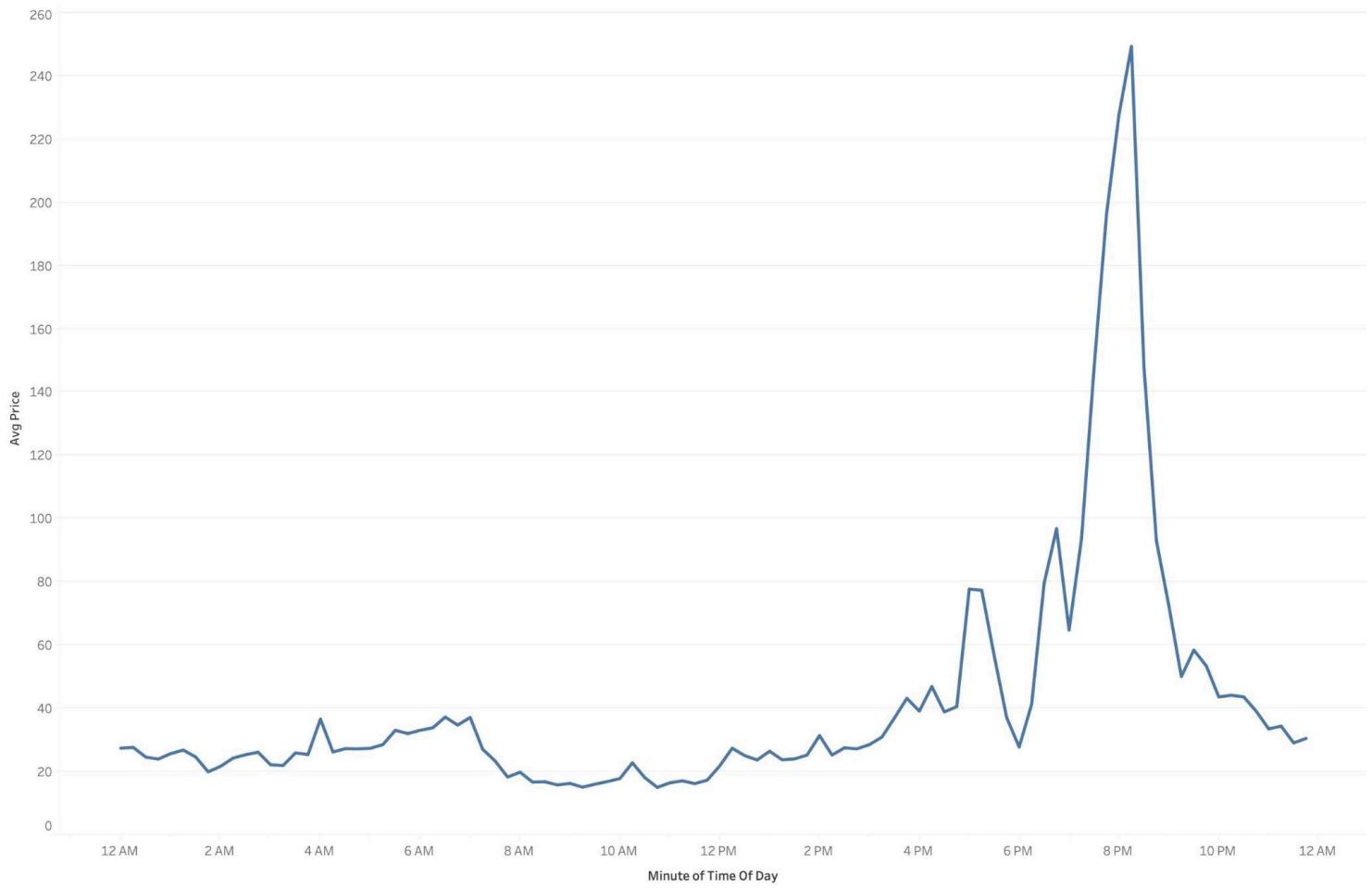


*Higher the Y, higher the profitability

Figure 5.1 Monthly Below Breakeven Electricity Price Frequency: May

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 5.2 Monthly Average Electricity per kWh: May

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-break-even electricity prices and the average price per kWh across a 24-hour period in May of 2024.

Key Insights:

12AM - 6AM:

- Unlike previous months, May sees a very strong start. Frequency values starting off at 6 by 12AM, just below the daily-high. Average prices are stable at around \$24/kWh but there are signs of a slightly upward trend as prices hit \$33/kWh at 6AM. This upward trend also brings about a downward trend in frequencies as it fell to just 1 at 6AM.
- Profitability Rate: 14.78%

6AM - 12PM:

- Beginning 7AM, frequencies rebound and reach 6 at 8AM and remain there. Simultaneously, average prices keep climbing until it reaches \$37/kWh at which point it plummets. Between 8AM and 12PM, a trough of low and stable prices form as it levels out around the \$16/kWh mark.
- Profitability Rate: 12.90%

12PM - 6PM:

- There is a slight hiccup between 1PM - 2PM where frequencies drop to 3 but it bounces back to 6 by 3PM and keeps increasing until it tops out at 7 by 6PM. Starting 12PM, a moderate hike in prices can be seen as it jumps from \$27/kWh at 12PM to \$77/kWh at 5PM before falling right back to \$27/kWh at 6PM.
- Profitability Rate: 14.65%

6PM - 12AM:

- A noticeable divot forms on the chart as prices jump to \$97/kWh at 7PM followed by a slight drop to \$64/kWh immediately after. However, this is not the highlight of the period as the prices surge to \$249/kWh at 8PM and this also is trailed by a huge drop, \$50/kWh at 9PM and \$30/kWh at 12AM. These dramatic changes are reflected in the frequency chart too as frequencies fell from 6 at 7PM to 0 at 8PM before a swift recovery back up to 6 at 11PM.
- Profitability Rate: 11.42%

Implications and Suggestions:

- Quality over Quantity:
 - Frequencies and Average prices are generally very stable aside from a few extreme surges in the late evening hours of 7PM and 8PM. This gives way to all day mild to moderate mining unlike previous months where only a few hours of the day were highly profitable while rest allowed for very little mining and barely profitable opportunities.
- 9-to-5 Cash Cow:
 - Even though the whole month was generally steady, there is a period between 9AM and 5PM where prices are the lowest and frequencies are the highest. This period presents the most optimal period for mining for the month of May

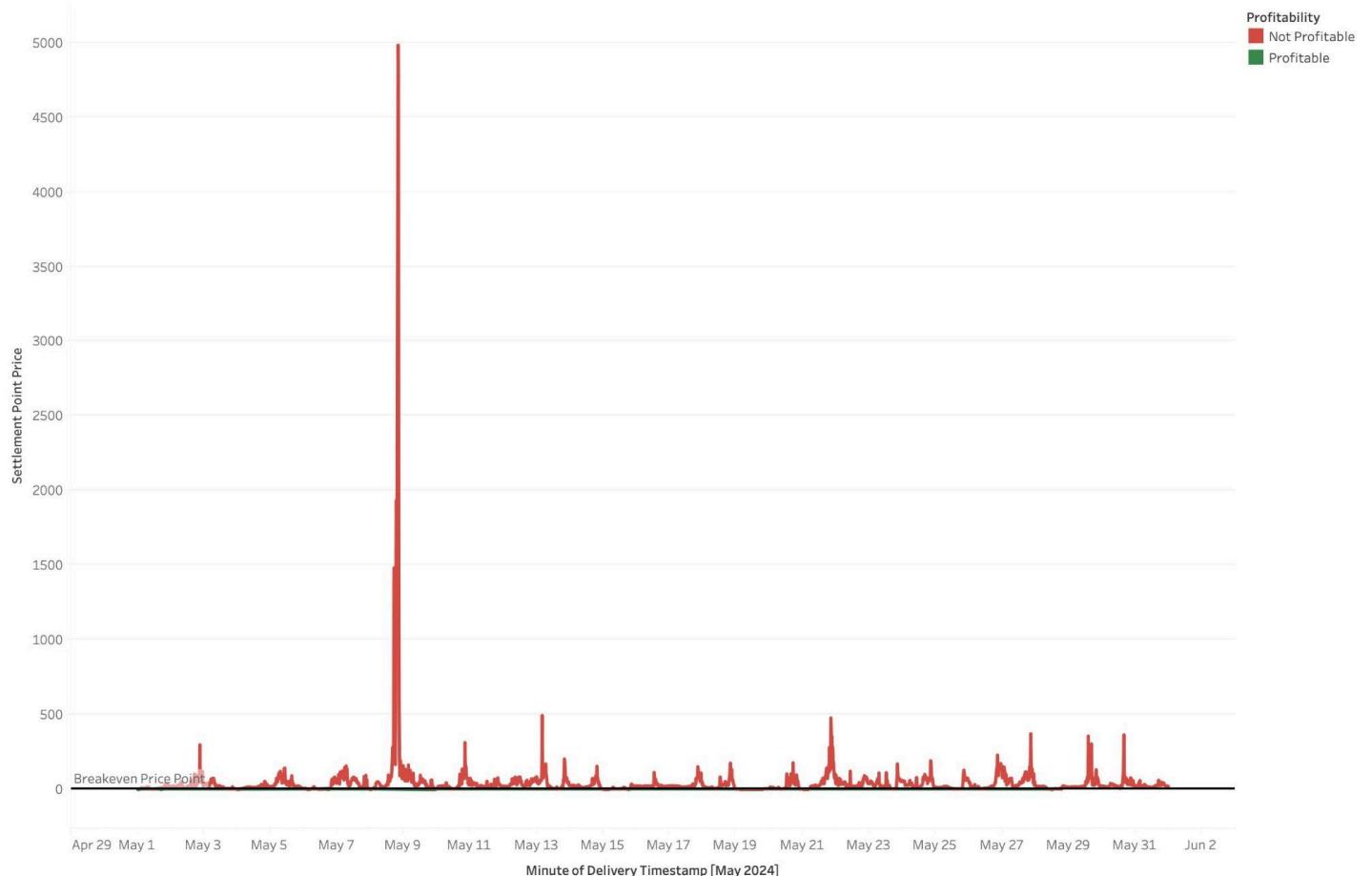


Figure 5.3 Monthly Profitability: May

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 5.3 above shows daily electricity prices for May 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

Profitability Rate: For May, mining was profitable 13.44% of the time, managing to beat the yearly average of 10.28% by 30.74%.

Trends:

- Aside from a few setbacks where prices skyrocketed to over \$5,000/kWh, that is almost 120 times more than the mean price for the month which is \$41.08/kWh and more than 250 times the median price of \$19.4/kWh, an anomaly in the energy industry.
- Prices were stable for the most part throughout the whole month, Standard deviation in the profitability rates across the 4 6-hour periods was 1.59%, that's 76.86% less than the average standard deviation across 2024 of 6.87%.

Conclusion: May was one of the most stable months of the year while also remaining relatively profitable as it marks the end of the Spring Bonanza. While it may seem underwhelming compared to the earlier months of the Spring Bonanza, May still suprasses the upcoming Summer months cumulatively in terms of profitability.

June Report: Electricity and Mining Trends

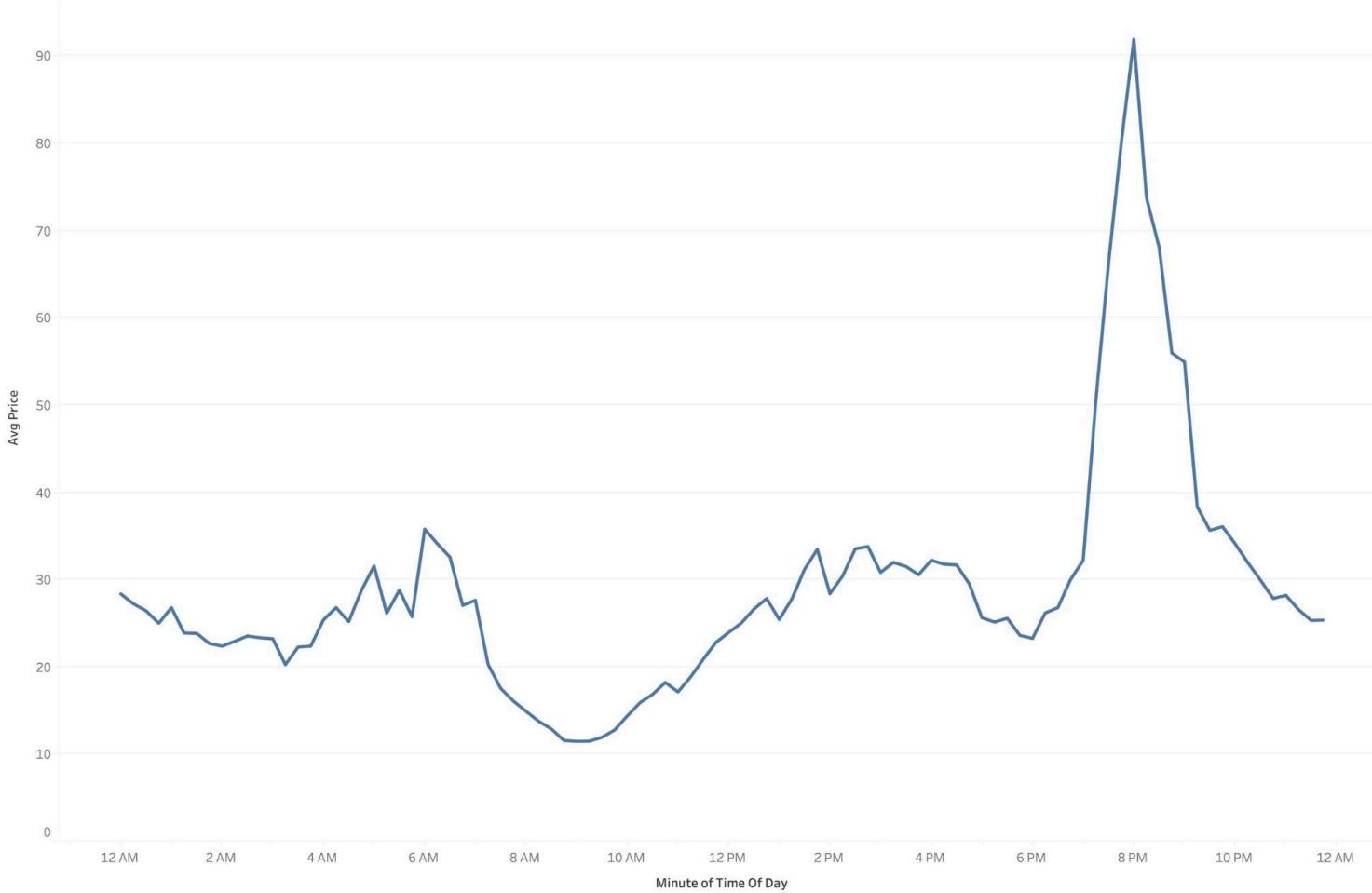


*Higher the Y, higher the profitability

Figure 6.1 Monthly Below Breakeven Electricity Price Frequency: June

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 6.2 Monthly Average Electricity per kWh: June

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-break-even electricity prices and the average price per kWh across a 24-hour period in June of 2024.

Key Insights:

12AM - 6AM:

- This period is relatively quiet, there is not much room for mining as there are sights of very minimal mining between 12AM and 3AM, frequencies are stable at 0 after 3AM. Average prices are a bit more volatile, starting off at \$28/kWh at 12AM, dropping to \$20/kWh at 3AM before shooting up to \$35/kWh at 6AM.
- Profitability Rate: 0.69%

6AM - 12PM:

- Not much happening at the start of this period either, frequencies are at 0 between 6AM and 8AM. But things take a turn for the better past 8AM, below-breakeven price frequencies skyrocket to 8 and remain there until 10AM which marks the daily-high. However, mining opportunities slowly diminish past 10AM as frequencies fall to 2 at 12PM. This sudden movement can also be seen in the average prices as they fall from \$35/kWh to \$11/kWh at 9AM before jumping back up to \$24/kWh halfway through the day.
- Profitability Rate: 13.61%

12PM - 6PM:

- Frequencies are stable between 12PM and 3PM as it levels out at 2. Following this, there is a steady increase, leading to 4 instances between 5PM and 6PM. While frequencies remained steady, average prices increased from \$11/kWh in the morning to \$32/kWh by mid-afternoon before dropping to \$23/kWh at 6PM.
- Profitability Rate: 8.61%

6PM - 12AM:

- Frequencies begin at a positive note at 4 below-breakeven price instances until 8PM, where it sharply drops to 0 and remains there for the rest of the day. Average prices show steady growth, starting off at \$23/kWh at 6PM before spiking to \$92/kWh at 8PM. However, these prices are short lived as it drops down abruptly, reaching \$25/kWh at 12AM.
- Profitability Rate: 4.44%

Implications and Suggestions:

- Short Mining Windows:
 - With only two 2-hour windows offering significant profitability, miners should focus efforts on these concentrated periods. Late-morning hours of 9AM to 11AM is the most optimal mining period with 5PM to 7PM being a not so close but still steadily profitable second.
- Low but Consistent:
 - For longer and steadier sessions, a 12-hour session between 8AM and 8PM will be the best bet as it includes the highest frequencies and while offering lower prices compared to the rest of the day.

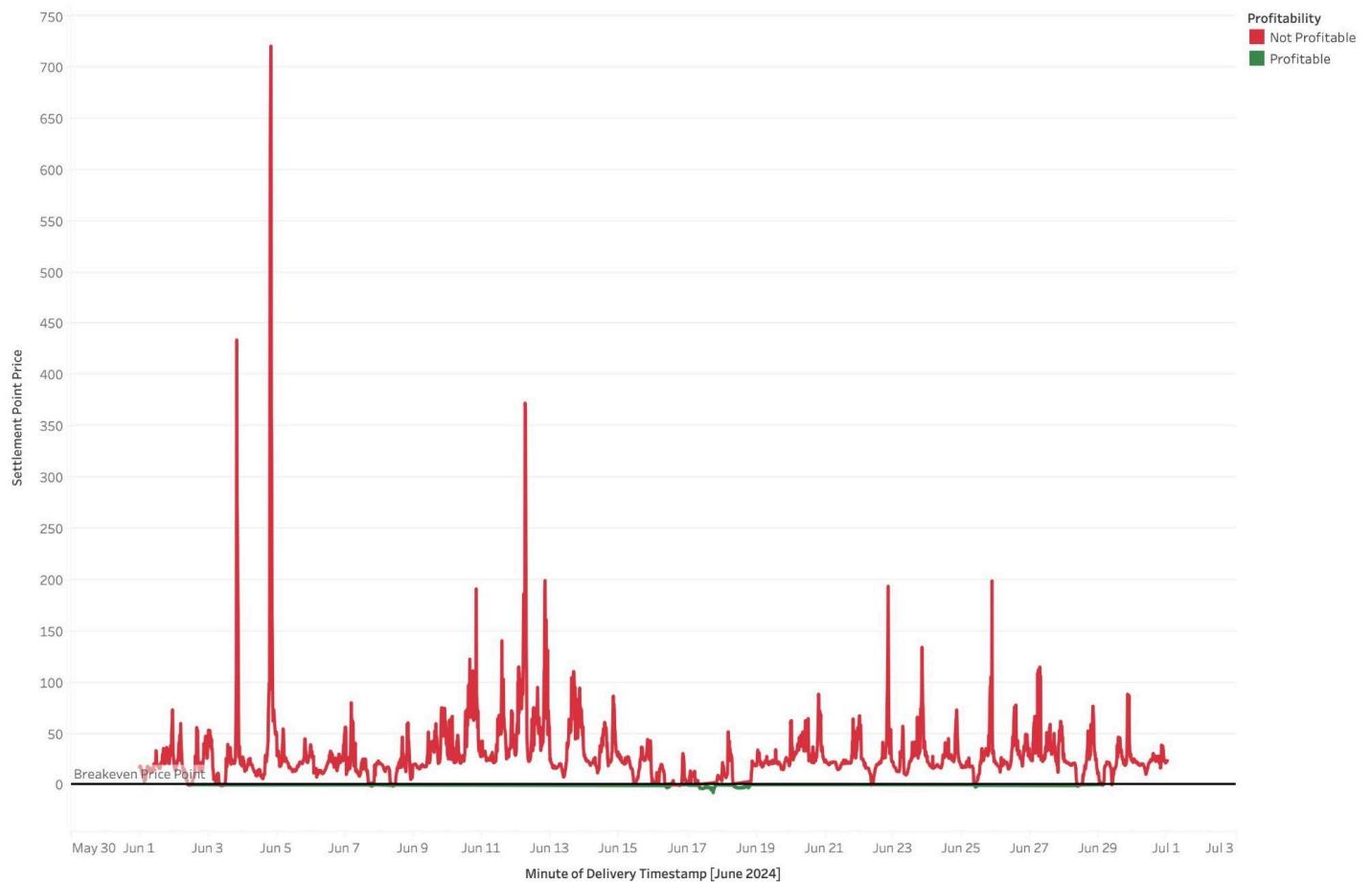


Figure 6.3 Monthly Profitability: June

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 6.3 above shows daily electricity prices for June 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

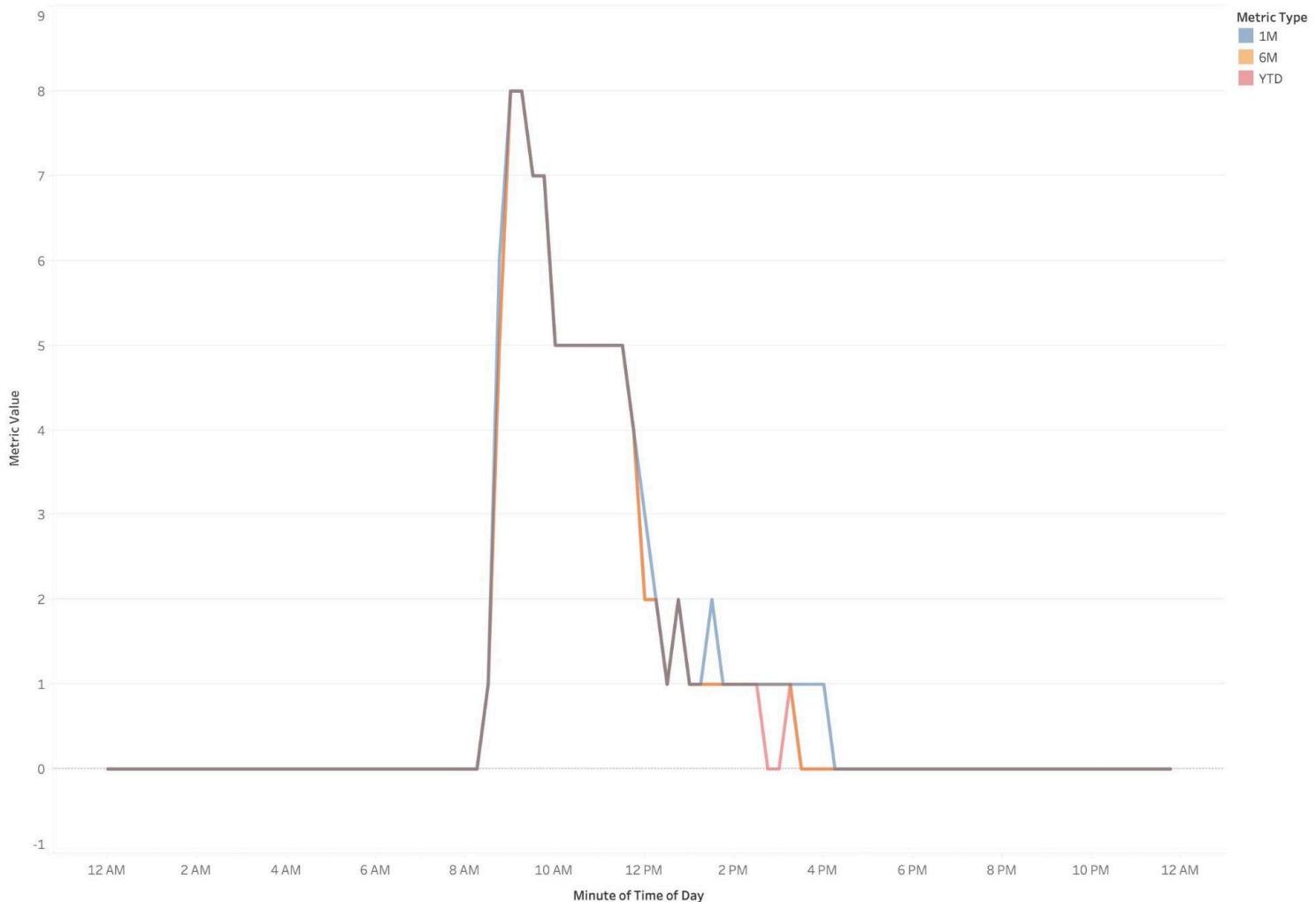
Profitability Rate: For June, mining was profitable 6.84% of the time, 33.5% less than the yearly average of 10.28%. This marks the first time profitability rate was below the yearly average for 2024.

Trends:

- Although June experienced fewer price spikes compared to earlier months, stability isn't the only factor when it comes to profitability and its generally high baseline electricity costs contributed to limited mining opportunities.

Conclusion: June marks the beginning of the summer slowdown for Bitcoin mining profitability. As temperatures rise and energy demand spikes, miners must plan carefully for this season, focusing on optimizing operations during off-peak hours.

July Report: Electricity and Mining Trends

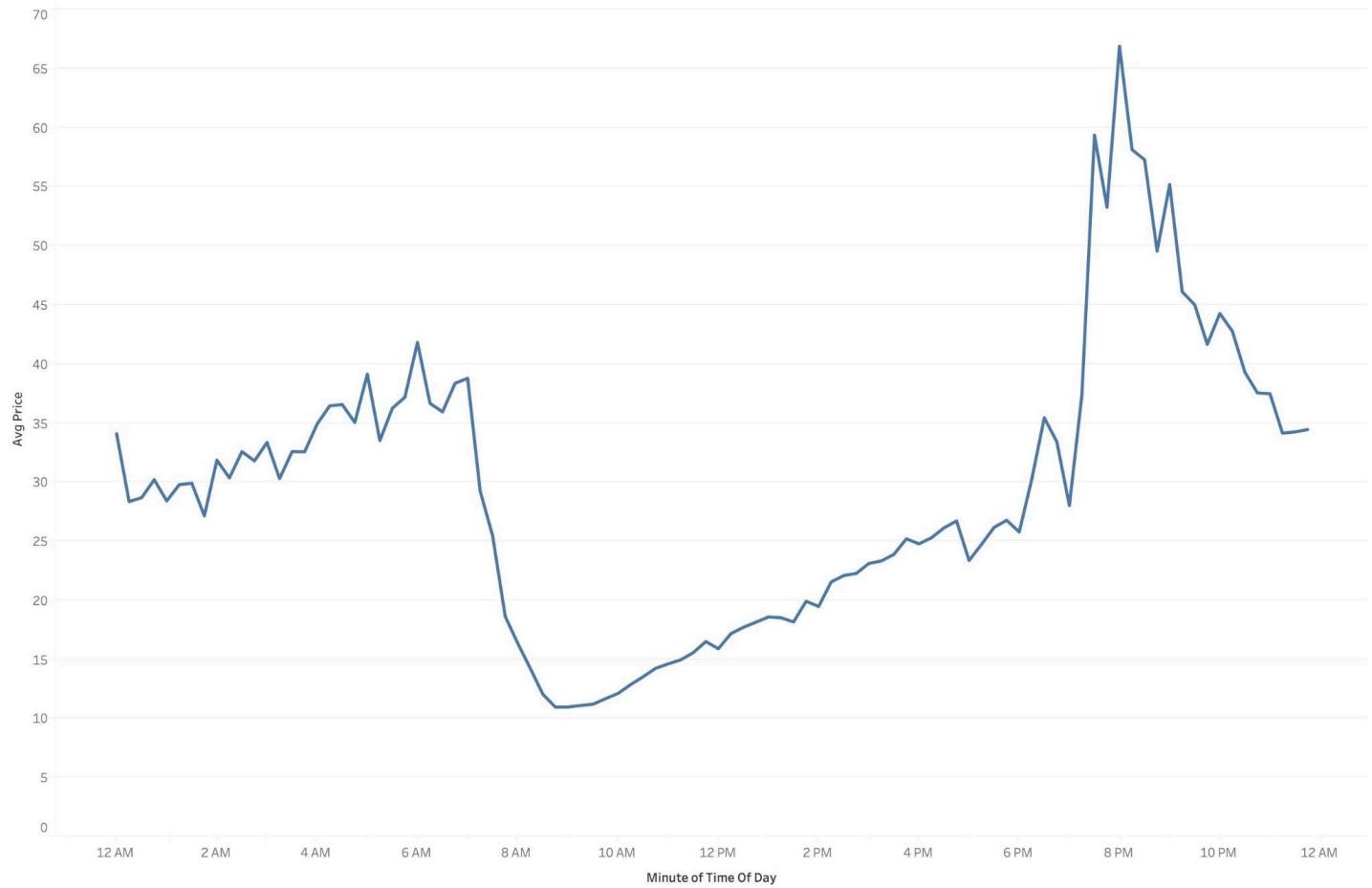


*Higher the Y, higher the profitability

Figure 7.1 Monthly Below Breakeven Electricity Price Frequency: July

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 7.2 Monthly Average Electricity per kWh: July

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-break-even electricity prices and the average price per kWh across a 24-hour period in July of 2024.

Key Insights:

12AM - 6AM:

- Profitability during July was virtually nonexistent as frequencies remain stagnant at 0 between 12AM and 6AM. Average prices are high for this time of the day as well. Prices begin from \$34/kWh and gradually increase to \$42/kWh by 6AM.
- Profitability Rate: 0%

6AM - 12PM:

- Frequencies begin at 0 but climb sharply after 8AM, peaking at 8 below-breakeven price occurrences by 9AM. This aligns with the month's lowest average price of \$11/kWh, observed at the same time. However, profitability quickly diminishes as frequencies drop to 3 by noon, accompanied by a gradual rebound in average prices to \$16/kWh.
- Profitability Rate: 10.22%

12PM - 6PM:

- The decreasing profitability trend makes its way into the afternoon and early evening as frequencies continue to fall, eventually bottoming out at 0 by 4PM. On the other hand, prices continue to rise, jumping from \$16/kWh at 12PM to \$26/kWh by 6PM with no intention of slowing down.
- Profitability Rate: 2.96%

6PM - 12AM:

- The last 6 hours of the day displays no profitability as frequencies remain static at 0 while average electricity prices continue to increase. As seen in the previous months, the average price more-often-than-not peaks around 8PM and this time around, it peaked at \$67/kWh before dropping back down and ending off the day at \$34/kWh.
- Profitability Rate: 0%

Implications and Suggestions:

- Pre-Noon Opportunities:
 - With profitability opportunities limited to a brief 3-hour window between 9AM and 12PM, miners should focus their operations during this time. Outside this period, mining remains unviable due to consistently high electricity costs
- Nothing before 8AM and after 4PM:
 - Operators must bide their time during these scarce profitability periods as opportunities are scarce and the data evidently shows that there has been no instance of profitable mining operations before 8AM and after 4PM.

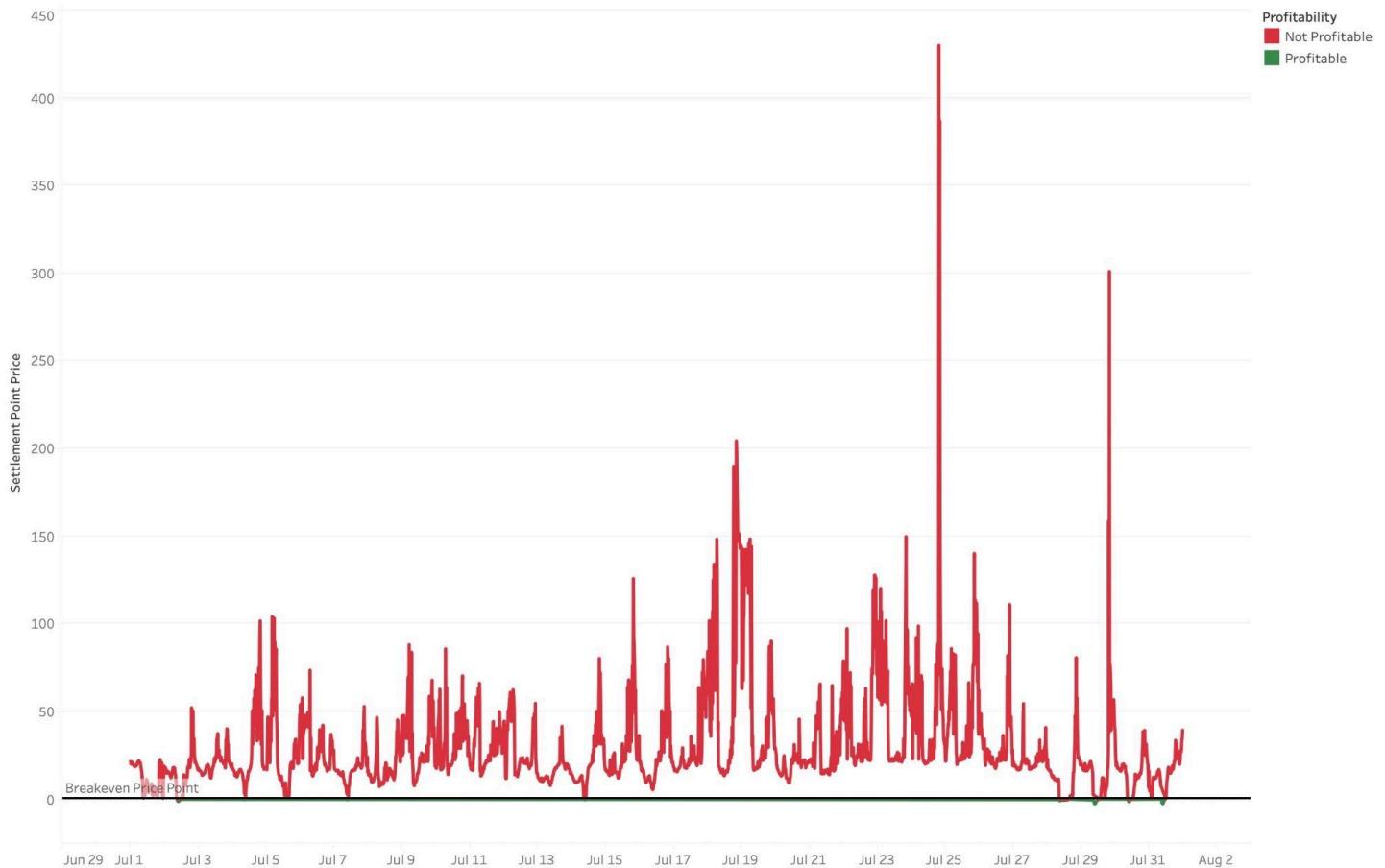


Figure 7.3 Monthly Profitability: July

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 7.3 above shows daily electricity prices for July 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

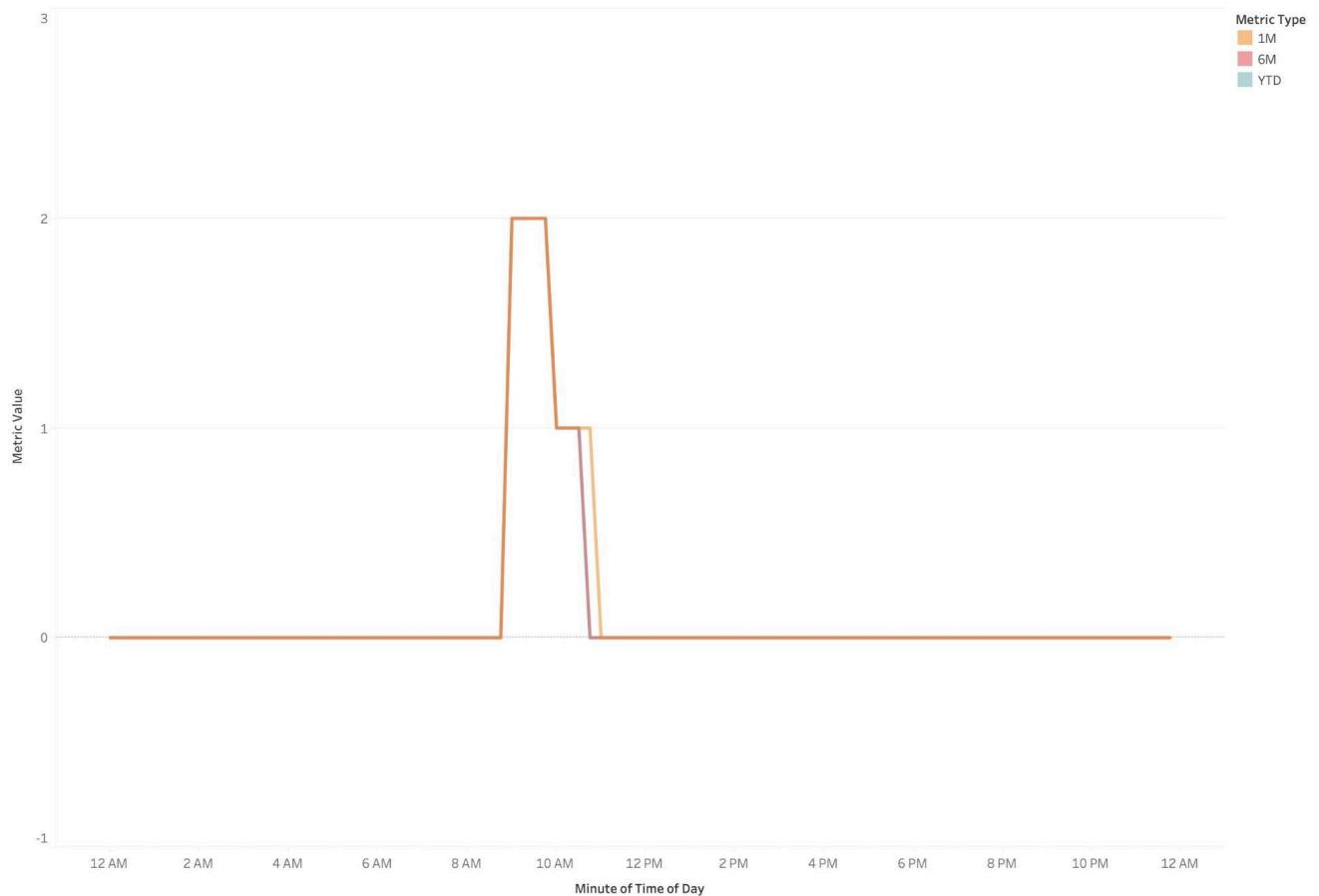
Profitability Rate: For July, mining was profitable 3.29% of the time, 68.01% less than the yearly average of 10.28%. As temperatures and other operational challenges such as cooling costs, grid instability, or peak demand pressures begin to increase, profits start to dwindle in correlation.

Trends:

- While July exhibited fewer price spikes compared to prior months, the consistently high baseline prices rendered mining largely unprofitable. As a result, prices were stable but also high, being above the breakeven line 96.71% of the time.

Conclusion: July demonstrates the compounded challenges of summer: rising temperatures, increased cooling demands, and heightened energy costs. With profitability restricted to 3.29% of the month, miners must focus on conserving resources and optimizing operations during the limited profitable hours. Strategic planning and resource allocation will be critical for enduring the summer and maximizing returns in the more favorable Fall and Winter months.

August Report: Electricity and Mining Trends

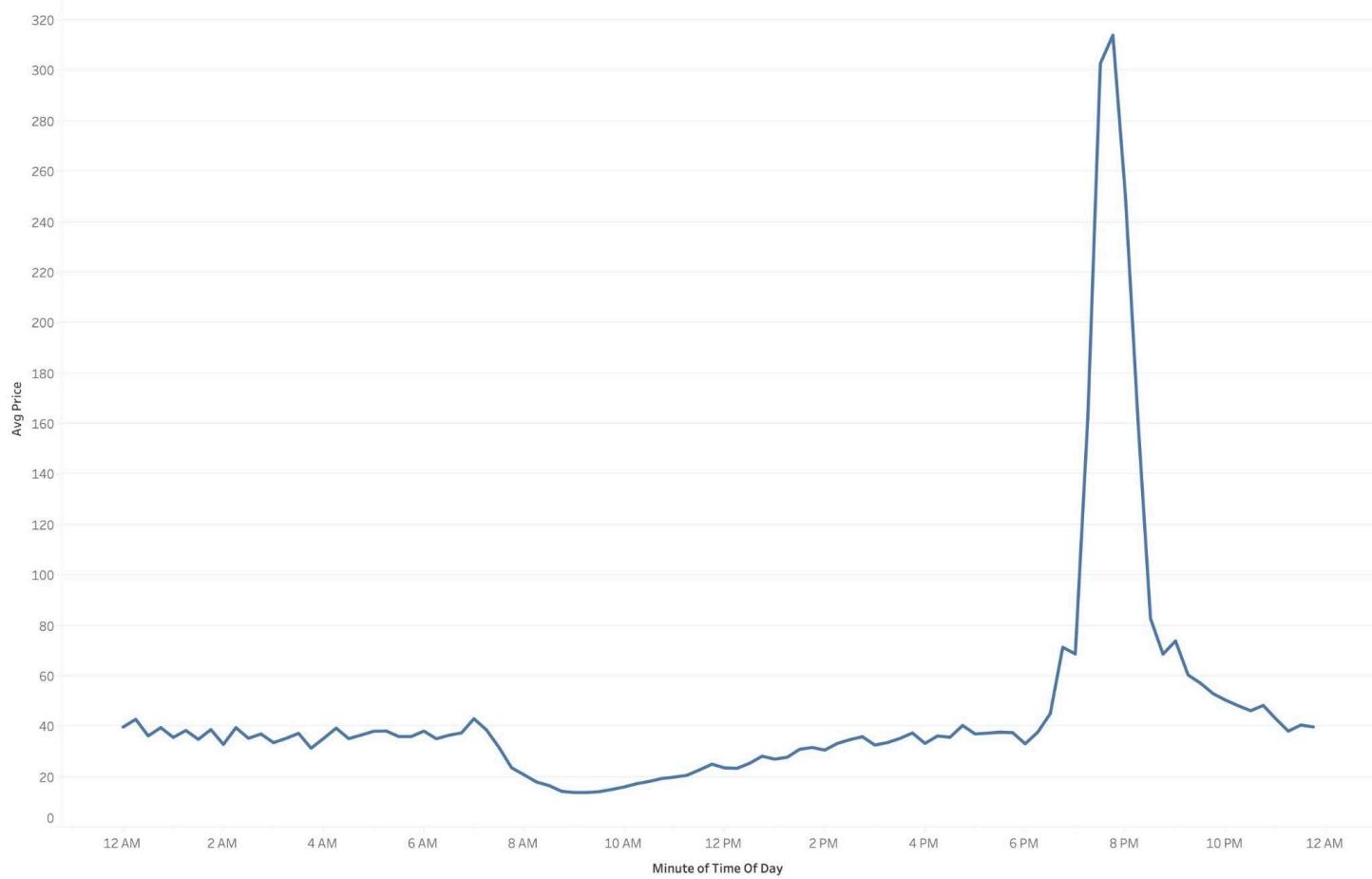


*Higher the Y, higher the profitability

Figure 8.1 Monthly Below Breakeven Electricity Price Frequency: August

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 8.2 Monthly Average Electricity per kWh: August

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-breakeven electricity prices and the average price per kWh across a 24-hour period in August of 2024.

Key Insights:

12AM - 6AM:

- August marked one of the most challenging months for profitability, with minimal mining opportunities across all time periods. There are no cases of profitability for the whole early morning as frequencies are at 0. Average electricity prices are on the higher side as well, alternating between \$38/kWh and \$39/kWh.
- Profitability Rate: 0%

6AM - 12PM:

- The little hope that remained for this month quickly dies down as the sharp upward trend that started past 8AM instantly caps itself at only 2 below-breakeven price frequencies at 9AM before bottoming out by 11AM. That very small window can be reflected in the average prices with figures falling from \$43/kWh at 7AM to \$14/kWh at 9AM before a gradual rebounding trend starts.
- Profitability Rate: 1.61%

12PM - 6PM:

- No sign of profitability, frequencies are flat at 0 while average prices have steadily grown from \$24/kWh at noon to \$38/kWh by early evening. These periods of consistent negative profitability could serve as downtime for operators to strategize and focus on the maintenance of miners and farms for the coming months.
- Profitability Rate: 0%

6PM - 12AM:

- The deal is more or less the same for the late evening and night hours as frequencies remain constant at 0. On the contrary, we see electricity prices surge from \$37/kWh at 6PM to a peak of \$302/kWh at 7PM and subsequently fall back down to \$37/kWh by the end of the day.
- Profitability Rate: 0%

Implications and Suggestions:

- Plan for the future:
 - Given the very limited mining opportunities presented during August, it would be the most optimal if operators directed their resources towards future mining opportunities. Baseline prices remain high, leaving little room for profitability.

- 1-hour Blitz:
 - If for any reason, operators have to make some profit in this unforgiving month, the 9AM–10AM window is the only notable period for potential profitability, with frequencies peaking briefly at 2 during this time. The rest of the day has proven to be highly unprofitable.

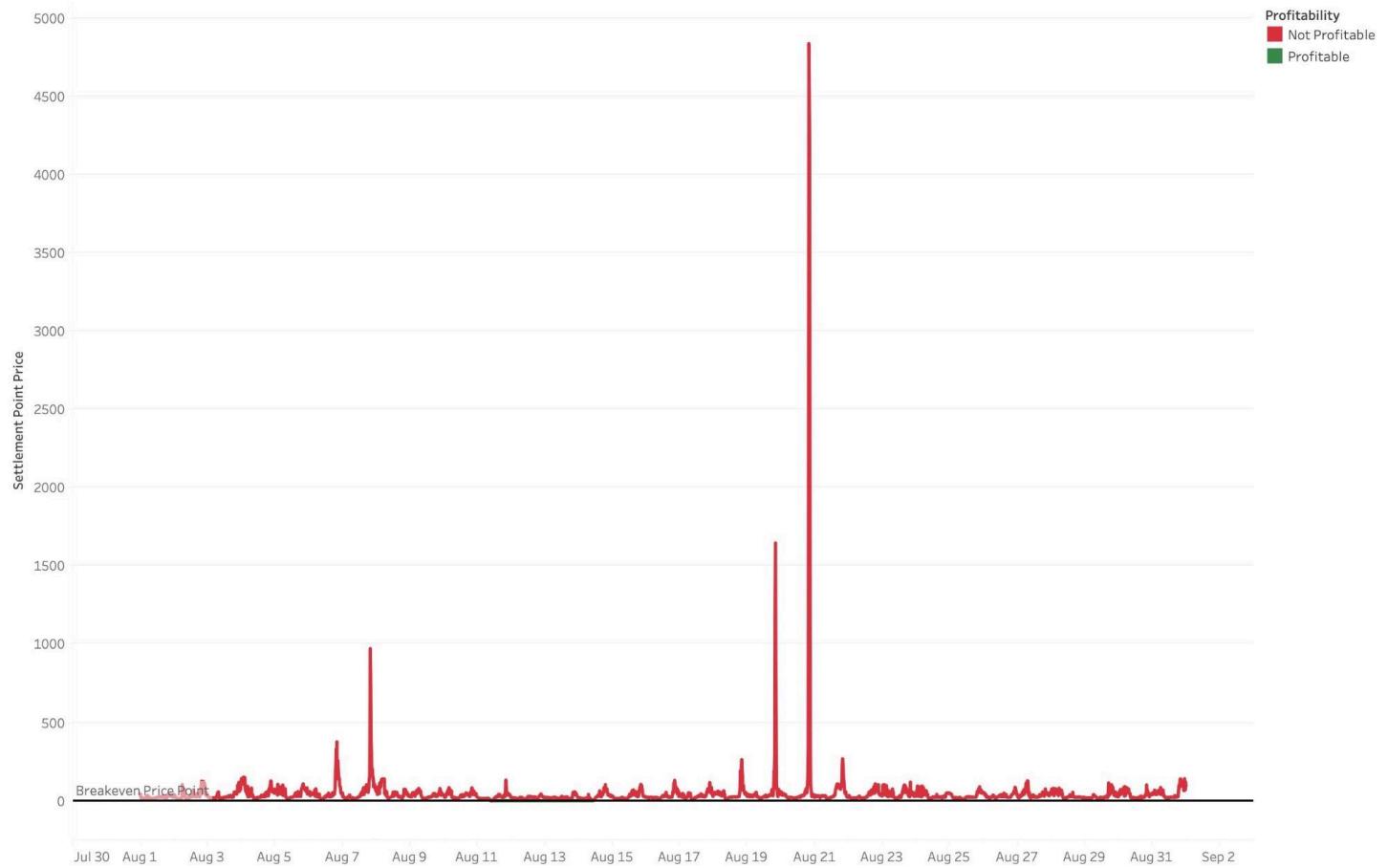


Figure 8.3 Monthly Profitability: August

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 8.3 above shows daily electricity prices for August 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

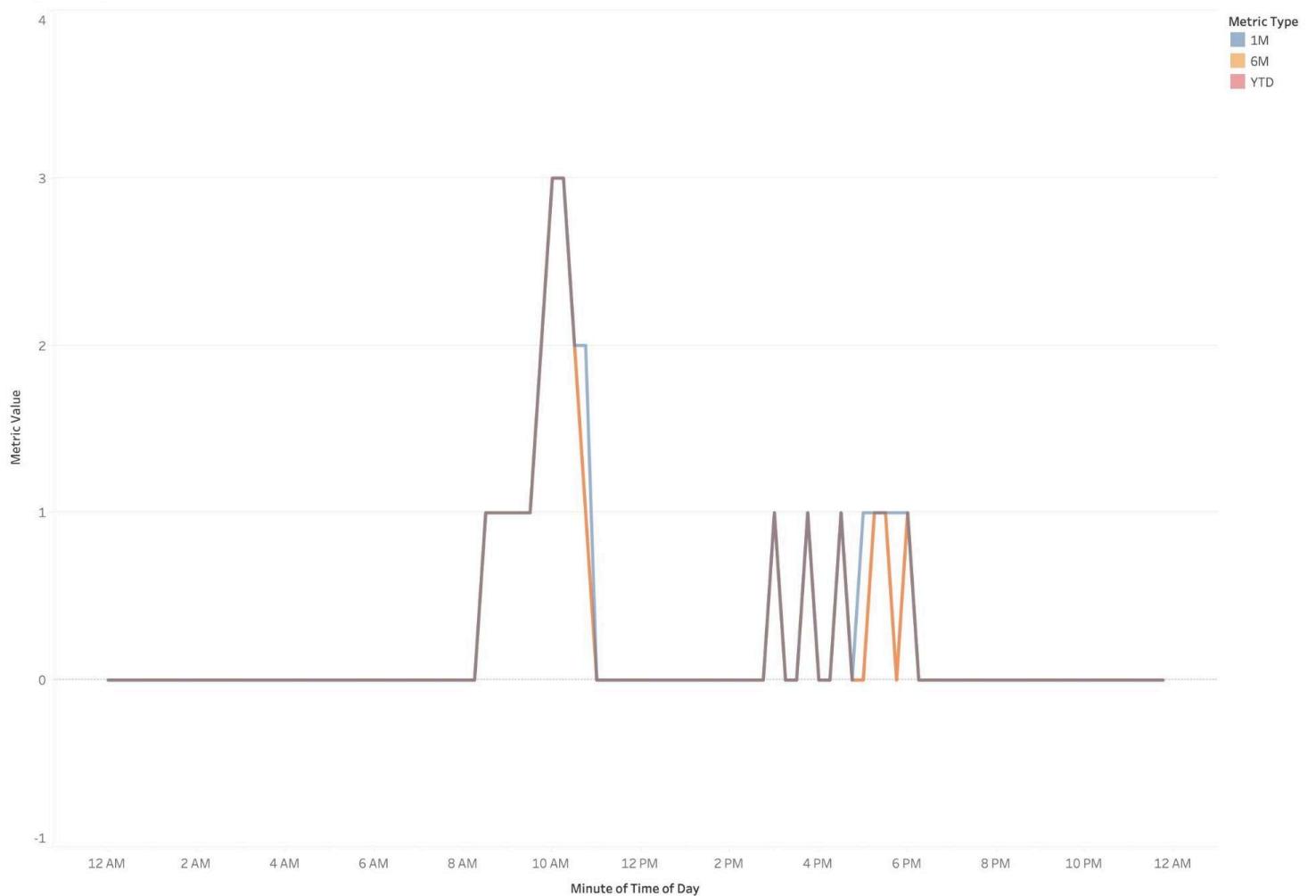
Profitability Rate: For August, mining was profitable 0.4% of the time, this means that even if we multiply the profits of August 25 times, it still won't equal the profit of a singular average month which has a Profitability Rate of 10.28%.

Trends:

- August experienced a myriad of unprecedented challenges, including price surges as high as \$4838/kWh—nearly 133 times the median price of \$27.56/kWh. The mean monthly price reached \$46.22/kWh, a record-high for 2024 and 29% above the yearly mean of \$36.23/kWh. This combination of extreme price volatility and a high baseline made August the least profitable month.

Conclusion: August presented a very tough time for mining as it exhibited virtually no mining opportunities. Less than 30 hours in August presented positive profit margins out of the total 744 hours. On the bright side, this quiet month could be used for bolstering and bracing for the more favorable conditions in the Fall and Winter months.

September Report: Electricity and Mining Trends

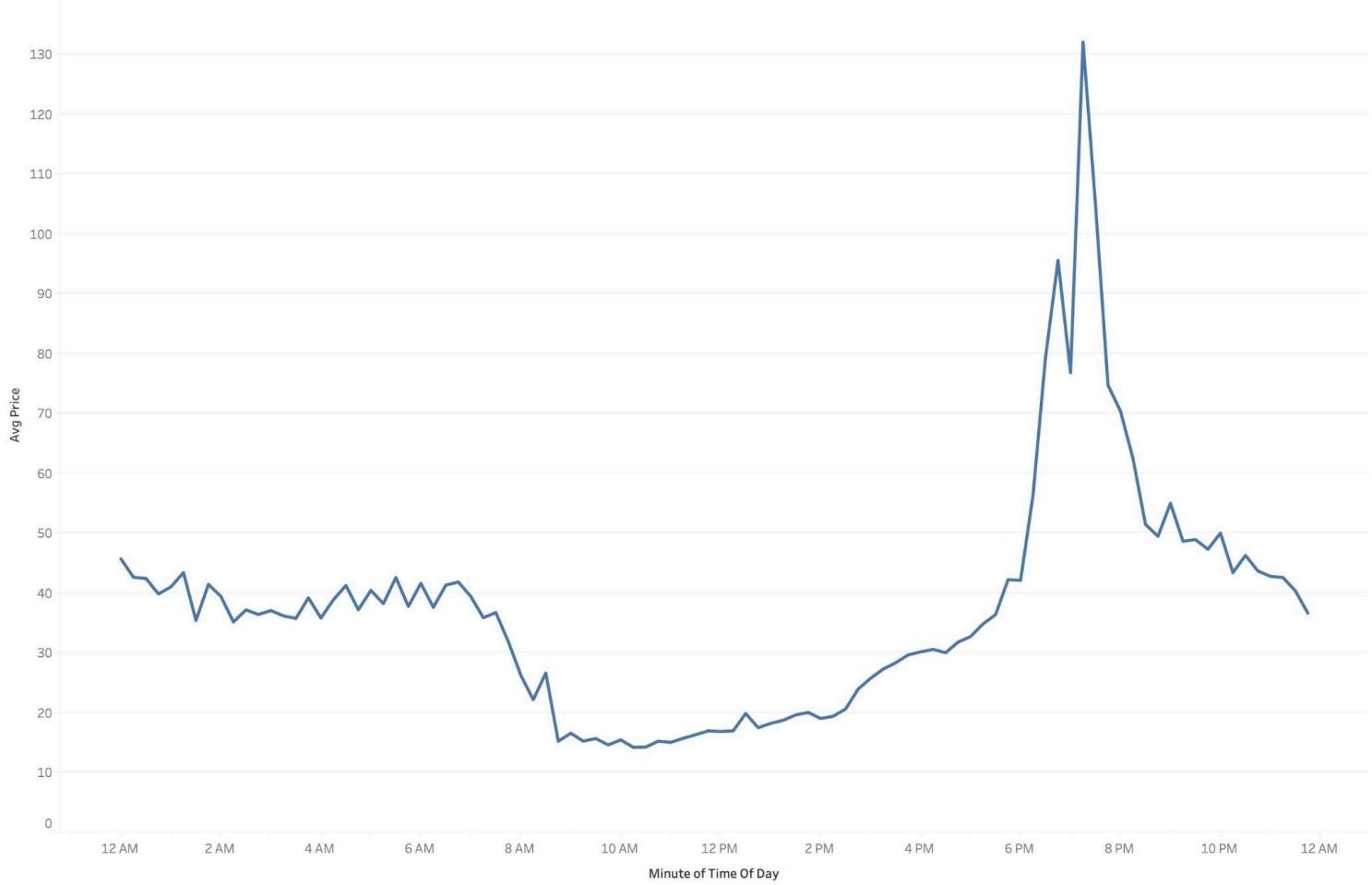


*Higher the Y, higher the profitability

Figure 9.1 Monthly Below Breakeven Electricity Price Frequency: September

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-break-even electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 9.2 Monthly Average Electricity per kWh: September

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-breakeven electricity prices and the average price per kWh across a 24-hour period in September of 2024.

Key Insights:

12AM - 6AM:

- Summer may be over but operational challenges stemming from high temperatures still persist. This can be proven through the wholly unprofitable early mornings of September while average electricity prices hover around \$40/kWh.
- Profitability Rate: 0%

6AM - 12PM:

- It's quiet for the beginning of the period but at 9AM, frequencies show some movement, reaching 1, and tripling to 3 by 10AM at its peak before dropping back to 0 at 11AM. Average prices tell a slightly different story as they are already decreasing by 6AM and bottom-out at 10AM hitting a daily-low of \$14/kWh before gradually rebounding back to \$17/kWh at 12PM.
- Profitability Rate: 2.36%

12PM - 6PM:

- Frequencies are stagnant at 0 until 3PM when there begins a very peculiar pattern where it alternates between 0 and 1 every 45 minutes until it hits its last 1 at 6PM. This unusual activity isn't reflected in the average prices as we can see it gradually grows from \$17/kWh at noon to \$42/kWh by evening. The reason as to why the two graphs have different patterns can be pointed back to the highly volatile prices where there most likely was an instance or two of below-breakeven prices during each of the mildly profitable periods.
- Profitability Rate: 0.97%

6PM - 12AM:

- Frequencies are stable at 0 following the last profitable time of the day, 6PM. On the contrary, prices more than tripled from \$42/kWh at 6PM to \$132/kWh at 7PM before dropping rapidly, hitting \$36/kWh at 12AM. Despite there being a sharp cut in prices, the drop wasn't significant enough to facilitate profitable mining sessions.
- Profitability Rate: 0.14%

Implications and Suggestions:

- Patience is Key:
 - Very much like August, September is a highly unprofitable period for mining. Rather than focusing on the present, operators should shift their efforts to coming months where the odds are much more likely to be in their favor.
- Limited Opportunities:
 - If miners are desperately seeking to make some profit during September, then the small windows between 9AM - 11AM and 3PM - 6PM provide the only viable opportunities, albeit with marginal profitability. While limited, these brief windows offer a glimmer of opportunity for operators seeking to offset losses during this challenging month.

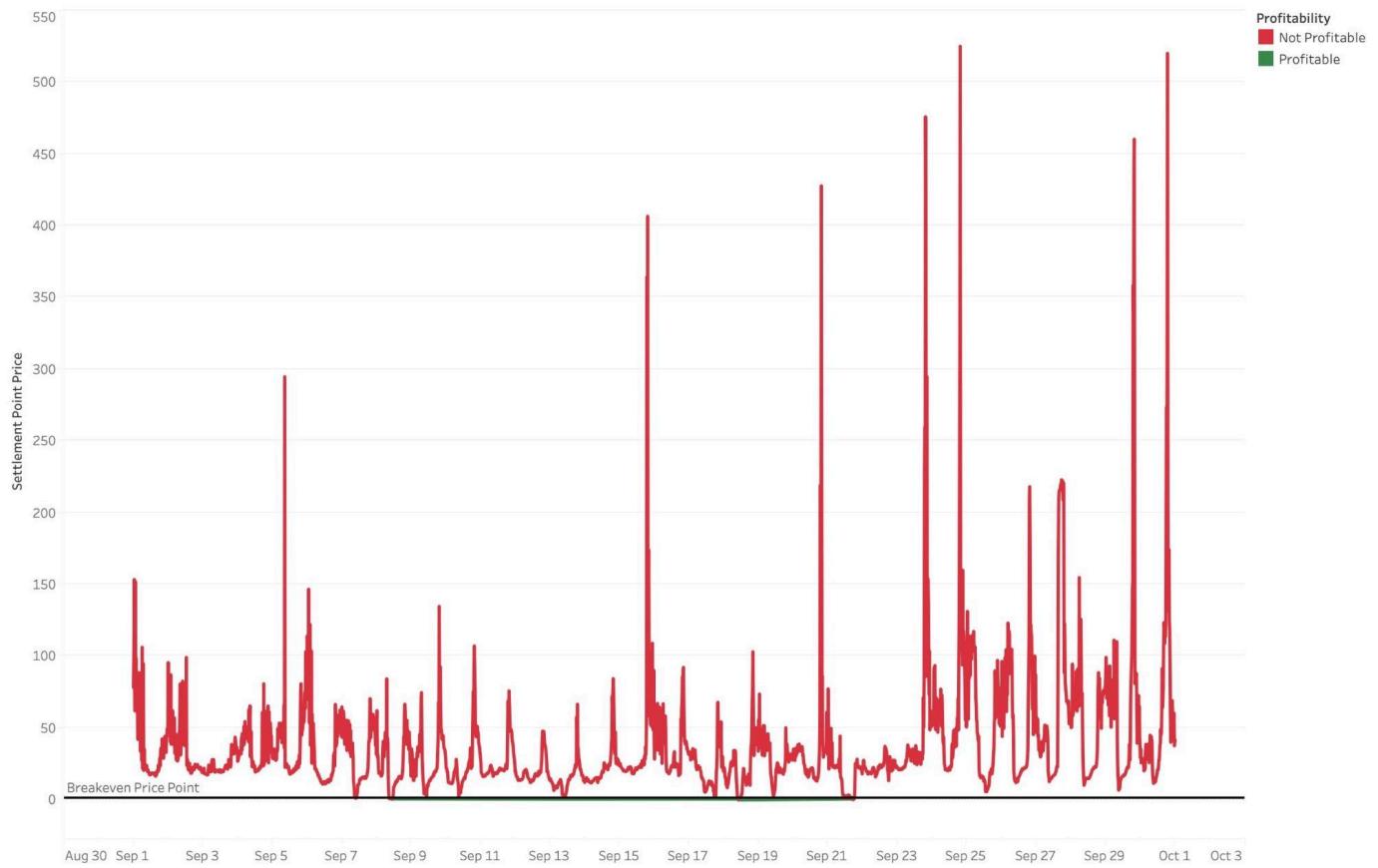


Figure 9.3 Monthly Profitability: September

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 9.3 above shows daily electricity prices for September 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

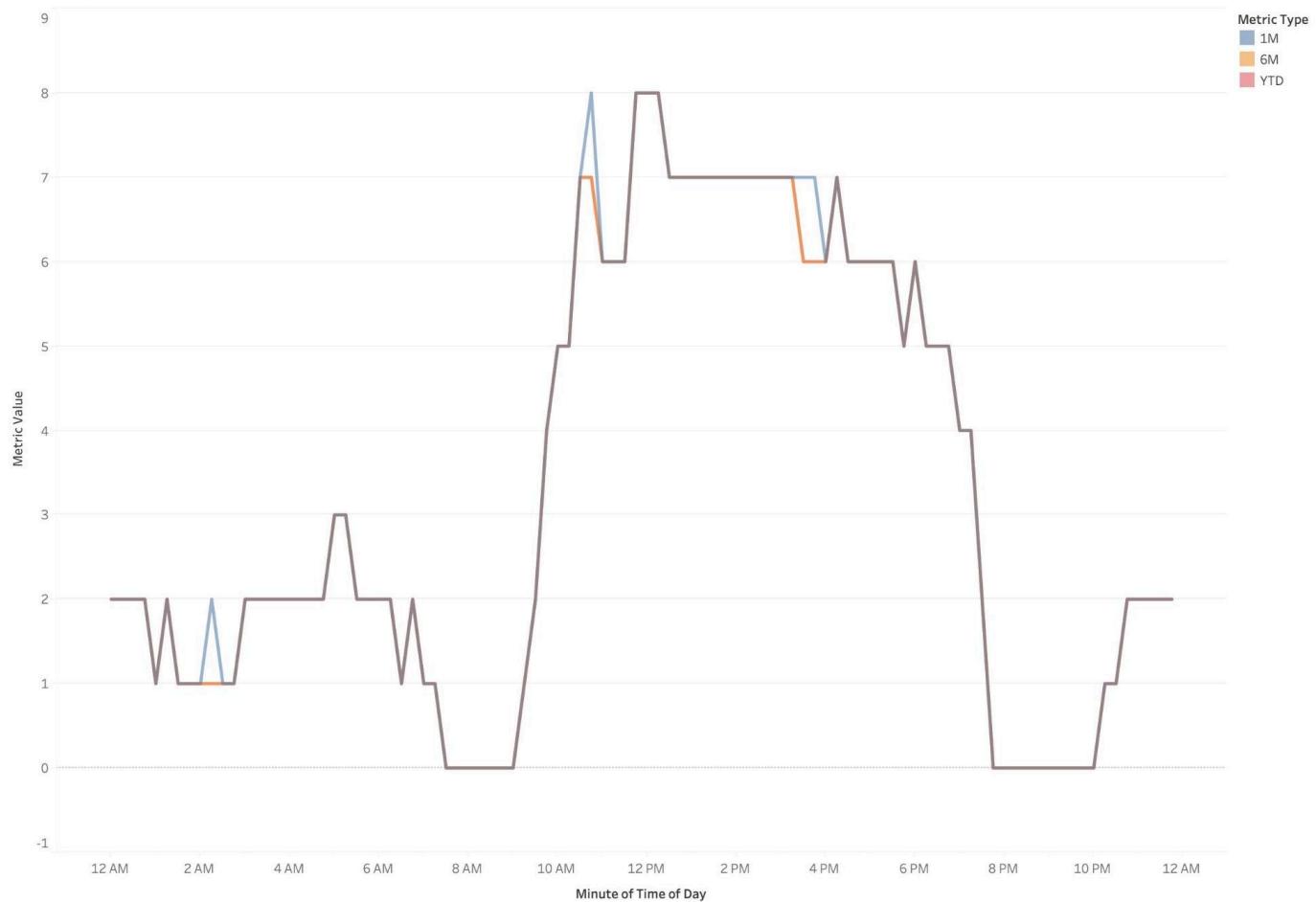
Profitability Rate: For September, mining was profitable 0.87% of the time, more than double of what it was in August(0.4%) but still nowhere near the yearly average of 10.28%.

Trends:

- September's mean and median prices, at \$37.25/kWh and \$23.71 respectively, reflect its position as one of the less favorable months for profitability. What made September the 2nd worst performing month of the year was the fact that the prices didn't have much volatility. While typically undesirable, price volatility can create brief profitable dips during high-baseline months like September that miners can swiftly capitalize on.

Conclusion: While September mirrored August's challenges, it offered slight improvements in profitability. The following months are significantly more profitable and miners can use this second month of downtime to strategize and best position themselves for the better times ahead.

October Report: Electricity and Mining Trends

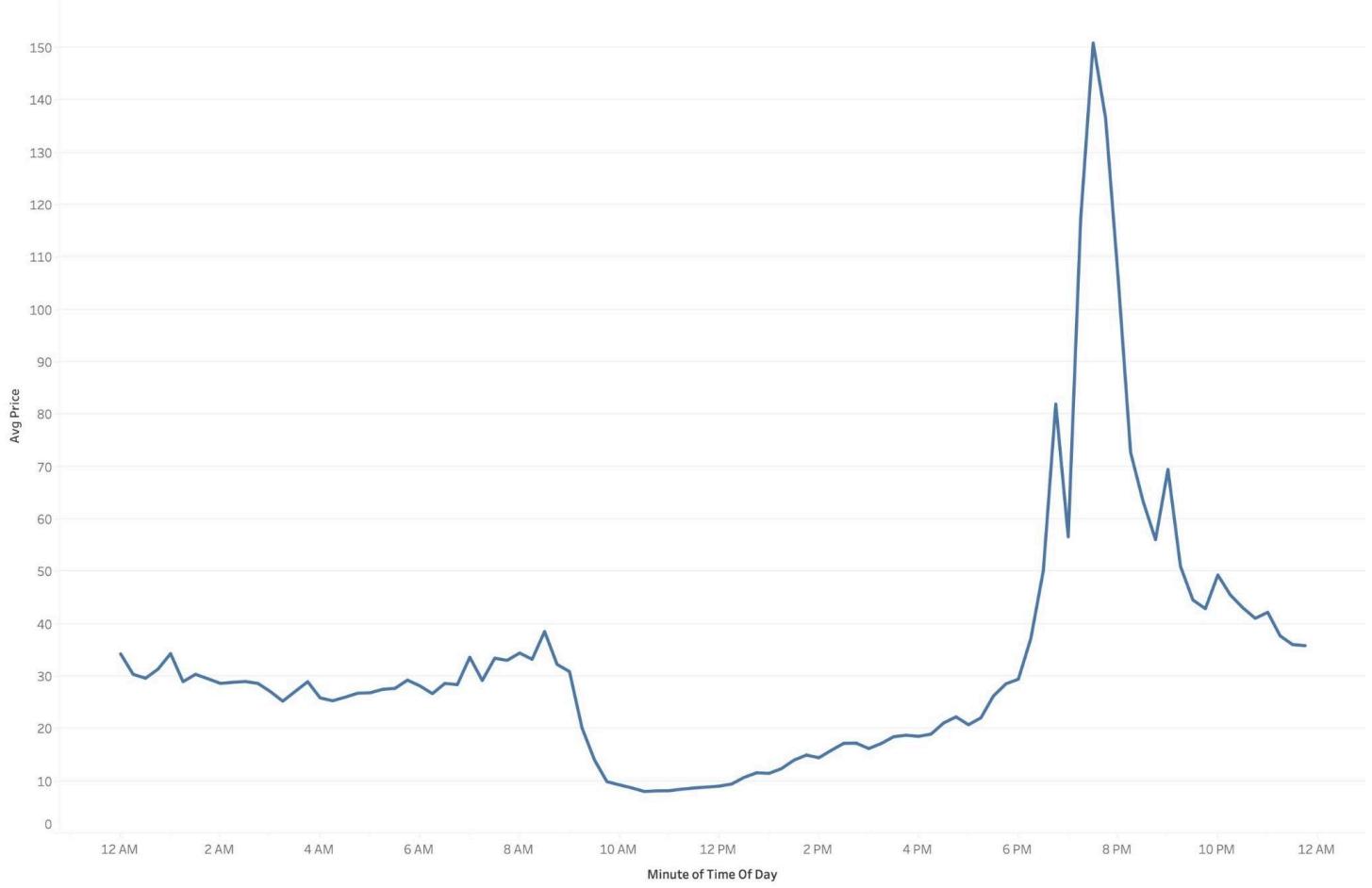


*Higher the Y, higher the profitability

Figure 10.1 Monthly Below Breakeven Electricity Price Frequency: October

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 10.2 Monthly Average Electricity per kWh: October

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-breakeven electricity prices and the average price per kWh across a 24-hour period in October of 2024.

Key Insights:

12AM – 6AM:

- The heat has gone and we see similar patterns that align with the early months of 2024 where the day kicks off stably and relatively profitable. Frequencies range between 0 - 3 but mostly remain at the 2 mark. The same can be said for the average electricity prices as it lingers around \$28/kWh without much volatility.
- Profitability Rate: 5.91%

6AM - 12PM:

- Beginning 6AM, a slow drop in frequencies begin as it falls to 0 between 8AM - 9AM. On the other hand, during this period of no profitability, average prices only went up to \$38/kWh. This precisely highlights the sensitive and minimal margin for error nature of Bitcoin mining.
- Shortly after 9AM, a strong upward trend in frequencies pick up as we see figures top out at 8 around 11AM. This pattern can be spotted in the prices charts too as prices plateau to \$8/kWh, a daily-low, at 11AM.
- Profitability Rate: 9.01%

12PM - 6PM:

- Frequencies are strong at 8 by 12PM. A mild drop sees figures drop to 7 and remain there until late afternoon before figures fall more drastically, eventually reaching 5 around 6PM. This can be mirrored by the average prices as it very steadily grew from \$9/kWh at 12PM to \$29/kWh by 6PM.
- Profitability Rate: 21.77%

6PM - 12PM:

- Frequencies keep falling while average prices keep increasing as a trough forms with 0 frequencies between 8PM - 10PM. Contrarily, prices shoot up from a modest \$29/kWh at 6PM to an astounding \$150/kWh closer to 8PM. This price however is only a spike as the average prices fall dramatically back down and reach \$36/kWh by the end of the day, this price allowed for minor mining opportunities as frequencies rebounded to 2 at 11PM.
- Profitability Rate: 5.78%

Implications and Suggestions:

- Mid-day action:
 - Following a harsh 3 months, Profitability is finally back up as we see consistently profitable periods, such as between 10AM and 7PM, where the cumulative profitability rate was 19.68% for a 9-hour window. This puts it as the most optimal mining period for October.

- Late-night and Early morning opportunities:
 - For operators seeking a less intense yet somewhat profitable off-peak mining period, the 7-hour window between 11PM and 6AM can serve as a great option with a profitability rate of 5.95%.
- Avoid Rush hour slumps:
 - Frequencies tend to hit rock-bottom between 8AM - 9AM and 8PM - 10PM as prices surge leading to no profits. The average prices for these two periods were \$26.68/kWh and \$57.11/kWh respectively.

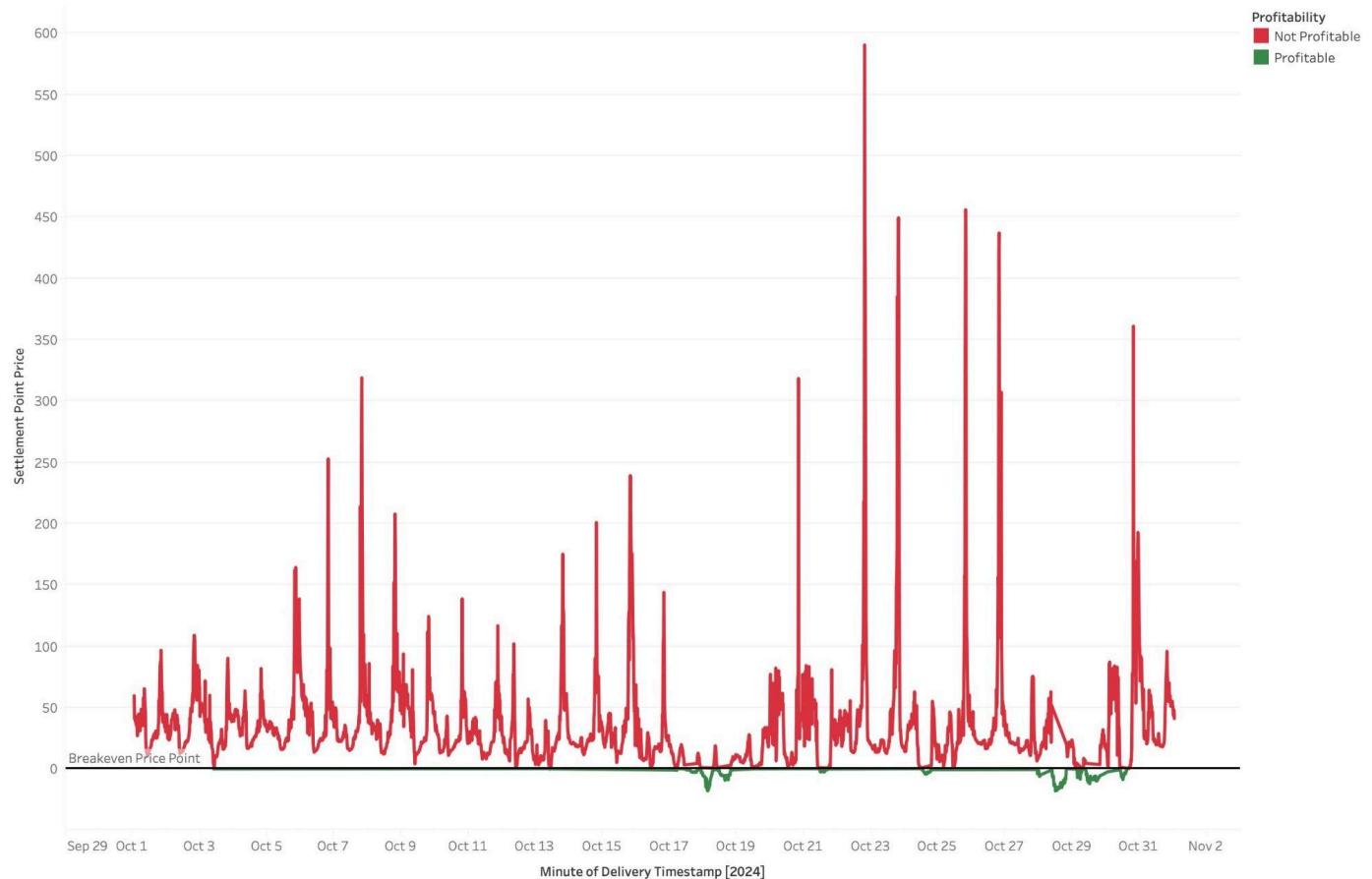


Figure 10.3 Monthly Profitability: October

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 10.3 above shows daily electricity prices for October 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

Profitability Rate: For October, mining was profitable 10.62% of the time, just barely scraping by over the yearly average of 10.28% but still significantly higher compared to the months.

Trends:

- Price surges were common, there have been 114 instances spread across 19 days of prices going well above \$100/kWh. These surges consistently occurred between 7PM and 8PM.
- October 16 - 20 proved to be the most significant period for mining as the profitability rate for this period was 23.96%, 129.77% more profitable than the monthly overall profitability rate.

Conclusion: October was a breath of fresh air following 3 months of below average mining months. Due to the combination of lower baseline prices and high volatility, there have been a fair bit of instances of low electricity prices allowing miners to expect consistent and acceptable profits.

November Report: Electricity and Mining Trends

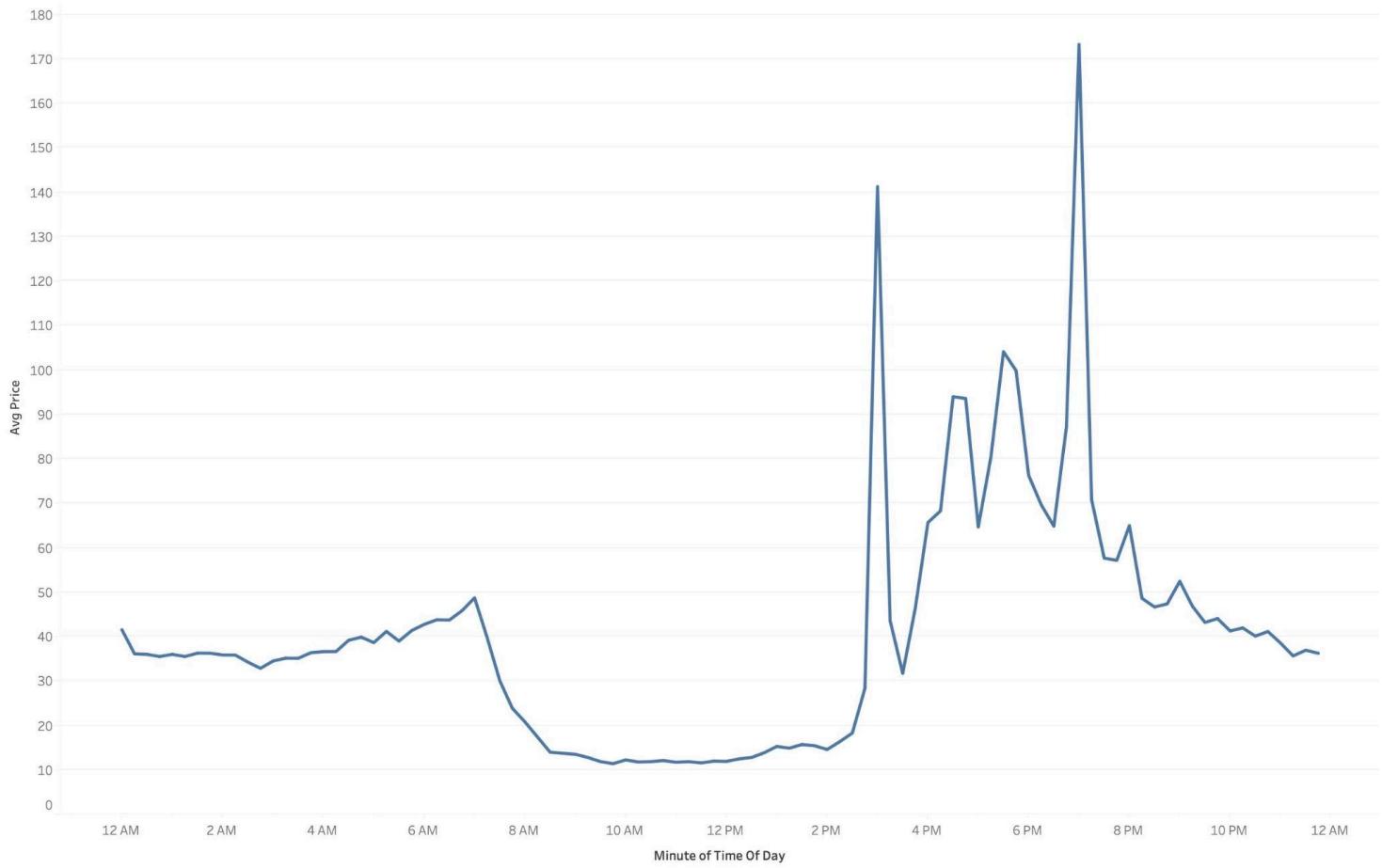


*Higher the Y, higher the profitability

Figure 11.1 Monthly Below Breakeven Electricity Price Frequency: November

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 11.2 Monthly Average Electricity per kWh: November

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-break-even electricity prices and the average price per kWh across a 24-hour period in November of 2024.

Key Insights:

12AM - 6AM:

- Early mornings of November were fairly stable, prices starting around \$35/kWh before slowly increasing, hitting \$42/kWh at 6AM. Despite high baseline electricity prices, early off-peak hours exhibited signs of mild profits with below-breakeven price frequencies ranging between 1 and 2.
- Profitability Rate: 4.17%

6AM - 12PM:

- Early morning price hike tops out \$49/kWh by 7AM, accompanied by no profitability for this period. Following this, prices fall steeply, bottoming out at \$12/kWh pre-afternoon. This steep fall is mirrored by frequencies as it rockets from 0 frequencies at 7AM to a day-high of 9 at 9AM. Profitability remains on the higher side for the rest of the period as frequencies alternate between 7 and 9.
- Profitability Rate: 17.64%

12PM - 6PM:

- Stable and profitable times make their way into the late-afternoon as below-breakeven price frequencies linger around the daily-high frequency of 9. Prices are fairly stable well past 2PM hovering around \$14/kWh. However, at 3PM, things go south as prices surge to \$141/kWh followed by a mountain range of highs and lows where prices fluctuate heavily between ranges of \$32/kWh and \$100/kWh.
- The sudden price jump at 3PM is a very unusual sight given that profits were still high and more importantly mid-afternoon prices have never had this significant of a spike in the whole of 2024. However, take this surge with a grain of salt as it's mainly caused and skewed by one 15-minute interval instance of a price hike to \$3925/kWh in the whole of November.
- Profitability Rate: 19.03%

6PM - 12AM:

- As a result of the highly fluctuating prices in the early evening, frequencies are stagnant at 0 until 9PM where frequencies grow to 1 as the downward trend that started from \$173/kWh at 7PM sees prices fall rapidly to \$52/kWh at 9PM. In the latter stages of the day, frequencies reach 2 as prices come down to \$36/kWh.
- Profitability Rate: 1.81%

Implications and Suggestions:

- Straightforward application:
 - Frequencies chart conveys a rather straightforward message, encouraging miners to divert their resources to the windows between 8AM and 4PM where average prices are around the \$13/kWh point for the most part while frequencies are fluctuating between a period-low of 7 and a period-high of 9. This window is the most profitable mining in November with an aggregated profitability rate of 23.89%
- Evening chaos:
 - Evening window between 5PM and 8PM is the least optimal window for mining as it presents a myriad of challenges including highly volatile prices with a standard deviation of \$171.43/kWh, a mean price of \$75.84/kWh, and a median price of \$49.41/kWh. All of these prices and values are at the top-end of the spectrum and go hand-in-hand with little to no profitability.

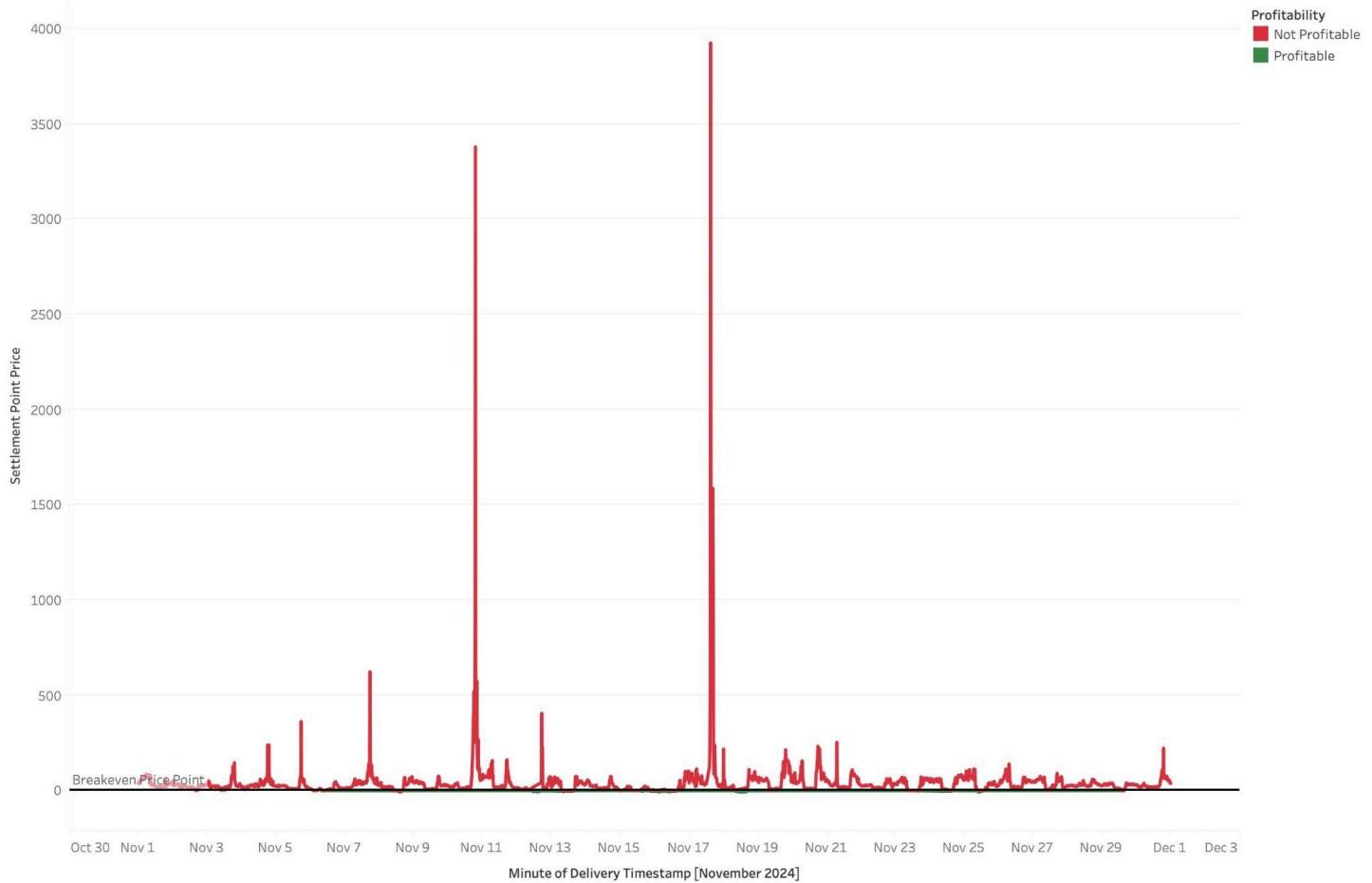


Figure 11.3 Monthly Profitability: November

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 11.3 above shows daily electricity prices for November 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

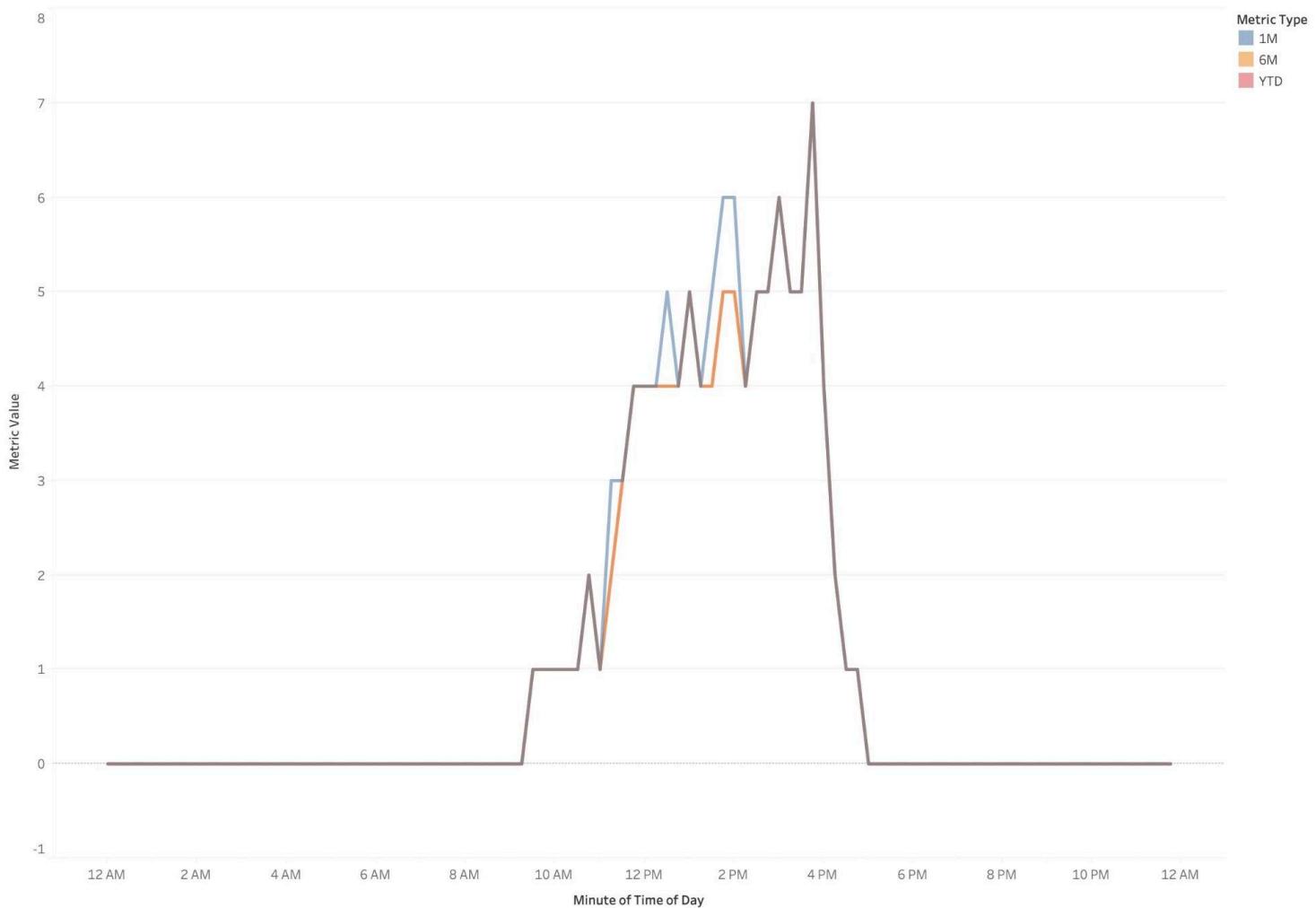
Profitability Rate: For November, mining was profitable 10.64% of the time, cutting it very close to the yearly average of 10.28%, and just 0.02% over the 10.62% profitability rate of October.

Trends:

- November, despite not seeming like it on the graph, was significantly more volatile than its predecessor, October, which was a volatile month by itself. For perspective, the standard deviation for October was \$30.94/kWh while November's came to a staggering \$119.56/kWh.

Conclusion: November was one of the most turbulent months of the year, in spite of having virtually the same profitability as October, it had completely different characteristics. Regardless of its unique patterns, it delivered solid profitability and stands as the last definitively profitable month of the year, with December falling short.

December Report: Electricity and Mining Trends

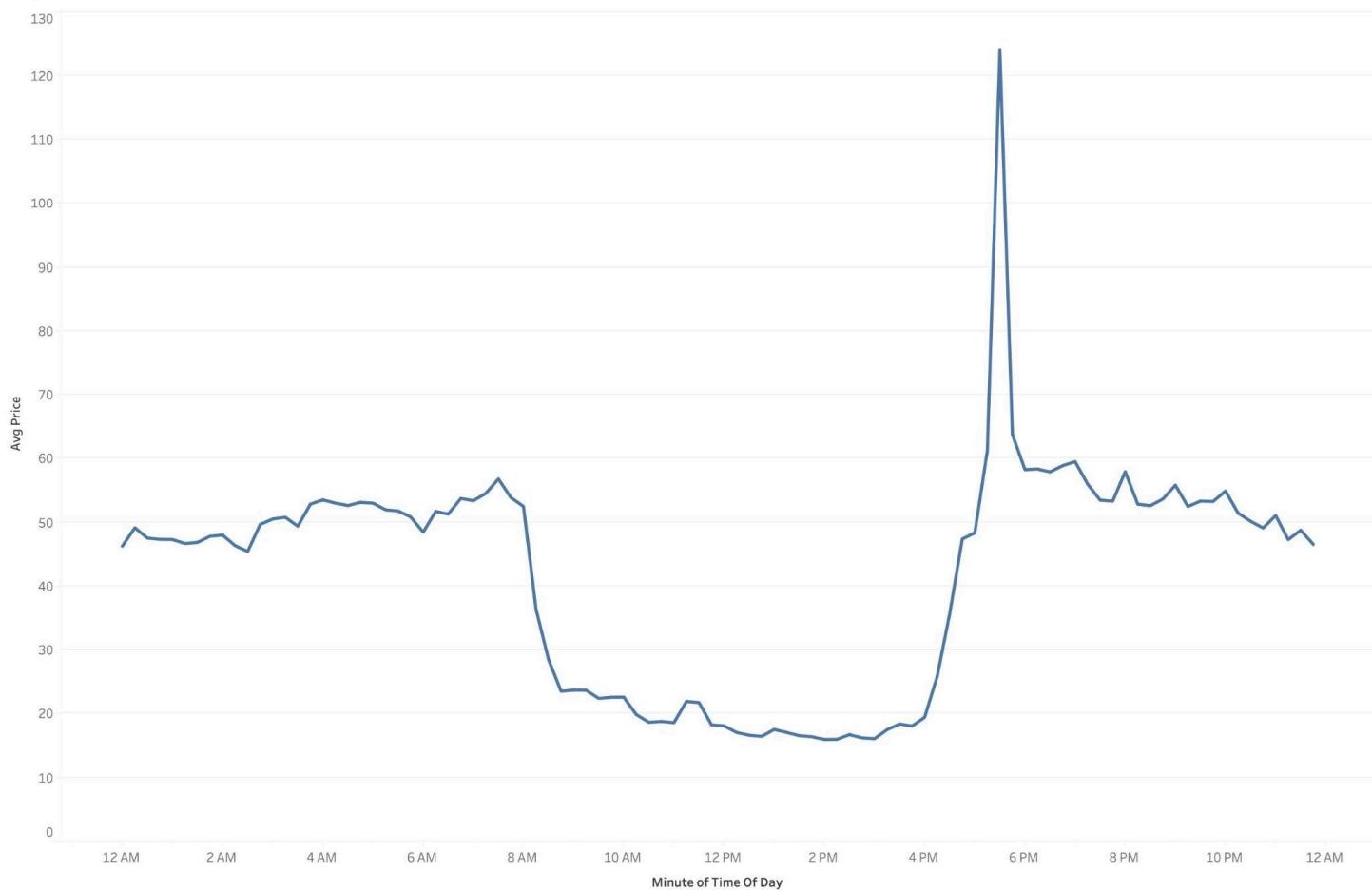


*Higher the Y, higher the profitability

Figure 12.1 Monthly Below Breakeven Electricity Price Frequency: December

X-axis: Time of Day in 15-minute intervals

Y-axis: Frequency of below-breakeven electricity prices in a given 15-minute interval for the month.



*Lower the Y, higher the profitability

Figure 12.2 Monthly Average Electricity per kWh: December

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview:

This analysis aims to deliver the most lucrative hours for mining based on the frequency of below-break-even electricity prices and the average price per kWh across a 24-hour period in December of 2024.

Key Insights:

12AM - 6AM:

- Average prices are high in the early hours, ranging between \$46/kWh and \$53/kWh. Consequently, baseline prices are elevated, yielding no profits between 12AM and 6AM.
- These low profitability months are brought about through a myriad of operational dilemmas such as increased demand, supply chain disruptions and more.
- Profitability Rate: 0%

6AM - 12PM:

- Frequencies remain minimal at 0 well into the later morning hours of 9AM. On the contrary, average prices started showing a strong downward trend, dropping from \$52/kWh at 8AM to \$23/kWh by 9AM. It's not long before frequencies start catching up with the dropping average prices as it shows a robust upward trend, hitting 4 by 12PM.
- Profitability Rate: 2.68%

12PM - 6PM:

- Below-break-even price instances retain their momentum throughout the early-to-mid afternoon period, cresting closer to 4PM at a frequency of 7. Similarly, average prices are progressively decreasing, hitting a daily-low of \$16/kWh in the mid-afternoon hours. Just as strongly and rapidly as the frequencies grew to a record-high for December, it fell with the same momentum, tanking to 0 at 5PM accompanied by price surges up to \$124/kWh.
- Profitability Rate: 13.1%

6PM - 12AM:

- Average prices more than half to \$58/kWh following a sudden spike in the early evening hours. Prices keep dropping though without as strong of an impulse, eventually reaching \$47/kWh at 12AM. Although price cuts were significant and stable, it was neither strong nor low enough to bring about any profitability. In other words, frequencies were unable to recover from the massive drop in the early evening and stayed minimal at 0.
- Profitability Rate: 0%

Implications and Suggestions:

- Early afternoon opening:
 - Following a very dormant morning, frequencies slowly picked up, hitting its initial sizable checkpoint of 4 at 12PM and reaching its peak of 7 closer to 4PM. Videlicet, the period between 12PM and 4PM is the most optimal period for mining in this suboptimal month, yielding a profitability rate of 15.71%.

- Off-peak lull:
 - In December, profitability was almost exclusively confined to on-peak hours, with off-peak periods showing no mining opportunities. In other words, refrain from conducting mining activities during the hours 5PM - 9AM as it's essentially a lost cause.

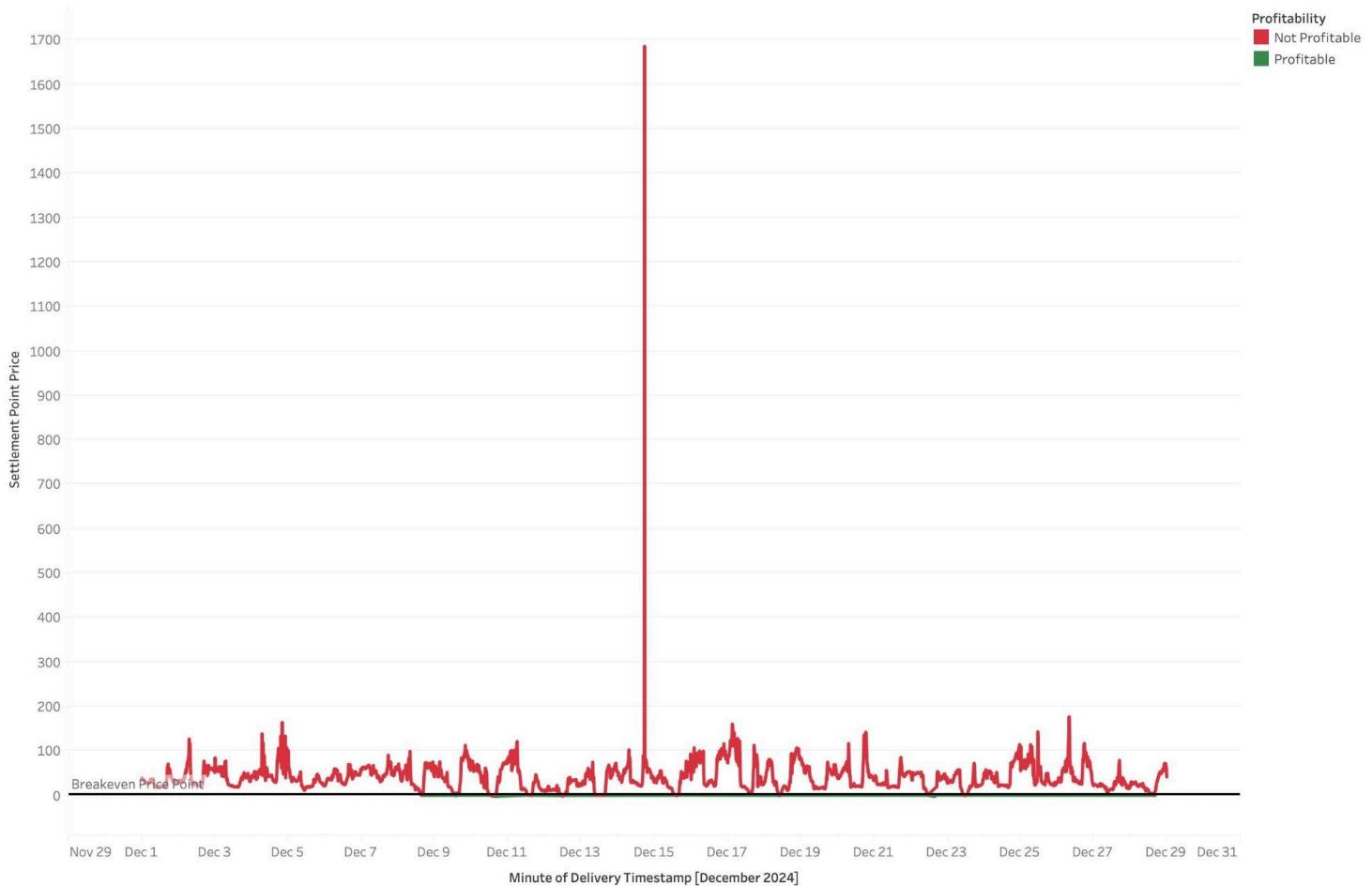


Figure 12.3 Monthly Profitability: December

X-axis: Time of Day in 15-minute intervals

Y-axis: Average price for Electricity per kWh in a given 15-minute interval

Overview: Figure 12.3 above shows daily electricity prices for December 2024 plotted at 15-minute intervals against a breakeven price reference line. Red indicates non-profitable periods, while green indicates profitable periods.

Profitability Rate: For December, mining was profitable 3.94% of the time, 61.67% less than the yearly average rate of 10.28%. This figure is in the same region as the hot unprofitable summer months albeit with temperatures on the opposite side of the spectrum.

Trends:

- December was a rather stable month with rare instances of off-the-charts price spikes. Regardless of that, baseline prices were high, resulting in subpar profitability.
- Mean price for the month was \$41.59/kWh which placed it in the 75th percentile for the year, while the median price was \$35.93/kWh which placed it in the 100th percentile by a huge margin. For context, the second highest median price for the year is \$27.56. Pairing these numbers with a modest 42nd percentile standard deviation of \$41.46/kWh, we get a combination that doesn't exactly equate to high profitability.

Conclusion: December didn't have many extremes, but a combination of unfavorable key figures meant that it wasn't going to be satisfactory. Akin to the hot temperatures that made mining difficult, there are many setbacks that stem from extreme cold temperatures such as increased energy demand, supply chain disruptions, natural gas production freeze-offs and more.

Discussion

Key Takeaways

This analysis demonstrates clear and highlighted seasonal and hourly patterns in wholesale electricity prices in the Western Texas Load Zone, optimized for Bitcoin Mining Operations.

The first few months of the year yielded the most profits and were regarded as the most optimal periods for mining on a month-to-month basis. January was an odd month compared to the rest of the months following it and shared more in common with December, as both had their most profitable hours tied to on-peak hours. On the contrary, the late winter and spring months had numerous profitable hours throughout the day, including both on-peak and off-peak hours, facilitating a variety of mining sessions such as early morning, mid-day, late evening, and more.

Halfway through the year, mining hit a wall, with frequencies topping out at 8 and only staying there briefly. Months like August and September were severely handicapped by operational challenges, seeing frequencies peak at 2 and 3, respectively, and profitability rates dropping into the decimals.

The later months of the year brought about a good recovery, with profitability rates surpassing the yearly average. However, the same pattern from the previous months persisted, with off-peak hours yielding little to no profits, thereby restricting mining to a small window during midday.

One trend was consistent across all months: most profitability occurred between the midday and on-peak hours of 9AM–6PM. This period consistently delivered the lowest and most stable electricity prices. Peak frequency was achieved either at the start of this period, towards the latter hours, or both, during peak profitability months.

Interestingly, the most common electricity price surges consistently took place within an hour before and after the most profitable period of the day (9AM–6PM), almost serving as its introduction and conclusion.

These findings emphasize the importance of strategic mining, critical timing, and the delicate nature of operations in this space, given the swift and significant price swings. By taking note of seasonal and hourly trends, miners can capitalize on the most profitable periods while mitigating losses during turbulent and strenuous times.

Challenges

This analysis was completed amidst a variety of challenges, primarily centered around integrating and aligning disparate datasets. One of the biggest hurdles was aligning the Bitcoin data, which was available in a much different format and time frame compared to the more detailed and intricate data from ERCOT. Extensive data cleaning and manipulation were required to ensure that the alignment was accurate and as reflective of real-world situations as possible.

Another significant challenge was the incompatibility of ERCOT data with PostgreSQL, followed by the lack of one-to-one compatibility between the custom SQL database and Tableau. This issue necessitated the creation of numerous tables for each month and extensive use of database tricks, such as dummy keys, to serve as workarounds and bridge the gaps.

Additionally, there were issues inherent to the data itself, such as extreme price spikes exceeding the thousands, which skewed the aggregated results considerably. This problem was mitigated by applying weighted averages and medians to ensure the analysis remained balanced and representative of typical trends.

Opportunities

Future analyses could greatly benefit from the inclusion of additional external factors, such as physical and environmental elements like extreme temperatures, energy demand fluctuations, and variations in energy sources.

Another critical layer to consider is compliance requirements, regulatory frameworks, and enterprise costs, encompassing taxes, operational expenses, fees, and other financial factors. Incorporating these dimensions would result in a more comprehensive analysis, improving accuracy and allowing for predictions with higher confidence intervals.

Furthermore, such an expanded framework could serve as a scalable template, enabling broader analyses at state, national, or even global levels. This approach would enhance the ability to adapt the methodology to larger-scale operations while maintaining accuracy and relevance.

Conclusion

This analysis was focused on unraveling and highlighting the trends and patterns in the Western Texas Load Zone and their implications on Bitcoin Mining operations. Despite limitations in the dataset, the study successfully identified the most optimal periods for mining across the year.

Key findings include the most profitable periods of the day for each month and the cumulative year, seasonal patterns, trends in electricity prices while also directly showcasing the impacts of operational challenges that stem from environmental circumstances like extreme temperatures, natural gas freeze-offs, and infrastructure vulnerabilities. While additional data points and factors could have enriched the analysis, it nonetheless captured the essence of Bitcoin mining within Texas's unique energy-only market.

This analysis fixates heavily on the criticality of timing and strategic planning in a market that stands apart from the national grid due to its high volatility and independent nature. By extending the time frame of the study and incorporating additional datasets and factors such as regulatory frameworks and comprehensive operational costs, this study can have a greater application beyond the Western Texas Load Zone while delivering greater reliability and confidence intervals.

In conclusion, this study serves as the stepping stone onto more dynamic and detailed analyses while providing valuable actionable insights and a high-level understanding of the structure of ERCOT's one-of-a-kind stance on energy pricing, storage, and distribution.

Appendix

SQL Queries

Miner Daily Revenue Calculation:

```
SELECT
    ("Hashrate (TH/s)" * "Bitcoin Mined per TH/s" * "Bitcoin Price (USD)") -
    ("Power Consumption (W)" / 1000 * 24 * "Electricity Price (USD/kWh)") AS "Daily Revenue
(USD)"
FROM miner_data_table;
```

Median Price Calculation:

```
SELECT
    PERCENTILE_CONT(0.5) WITHIN GROUP (ORDER BY "Settlement Point Price") AS
median_price
FROM prices_jan.prices_jan_table;
```

Settlement Point Prices between Specific Intervals:

```
SELECT *
FROM prices_jan.prices_jan_table
WHERE EXTRACT(HOUR FROM "Delivery Timestamp") BETWEEN 17 AND 20;
```

Standard Deviation of Settlement Point Price Calculation:

```
SELECT
    STDDEV("Settlement Point Price") AS "Standard Deviation"
FROM prices_jan.prices_jan_table
WHERE EXTRACT(HOUR FROM "Delivery Timestamp") BETWEEN 17 AND 20;
```

Monthly Profitability Rate Calculation:

```
SELECT
    DATE_TRUNC('month', "Delivery Timestamp") AS "Month",
    COUNT(*) * 1.0 / (SELECT COUNT(*) FROM prices_table) AS "Profitability Rate"
FROM prices_jan.prices_jan_table
WHERE "Settlement Point Price" < breakeven_price
GROUP BY DATE_TRUNC('month', "Delivery Timestamp");
```

Frequency Count Table Creation:

```
CREATE TABLE prices_dec.prices_dec_freq AS
SELECT
    EXTRACT(HOUR FROM "Delivery Timestamp") AS "Hour of Day",
    EXTRACT(MINUTE FROM "Delivery Timestamp") AS "Minute of Hour",
    COUNT(*) FILTER (WHERE "Settlement Point Price" < 0.258125) AS "Below Breakeven YTD",
    COUNT(*) FILTER (WHERE "Settlement Point Price" < 0.28175) AS "Below Breakeven 6M",
    COUNT(*) FILTER (WHERE "Settlement Point Price" < 0.3885) AS "Below Breakeven 1M"
FROM prices_dec.prices_dec_table
GROUP BY "Hour of Day", "Minute of Hour"
ORDER BY "Hour of Day", "Minute of Hour";
ALTER TABLE prices_dec.prices_dec_freq
ADD COLUMN "Time of Day" TIME;
UPDATE prices_dec.prices_dec_freq
SET "Time of Day" = ("Hour of Day"::TEXT || ':' || "Minute of Hour"::TEXT)::TIME;
```

Unpivoted Long Table Creation:

```
CREATE TABLE prices_jan.prices_jan_unpivoted AS
SELECT
    "Time of Day",
    'YTD' AS metric_type,
    "Below Breakeven YTD" AS metric_value
FROM prices_jan.prices_jan_freq
UNION ALL
SELECT
```

```

"Time of Day",
'6M' AS metric_type,
"Below Breakeven 6M" AS metric_value
FROM prices_jan.prices_jan_freq
UNION ALL
SELECT
"Time of Day",
'1M' AS metric_type,
"Below Breakeven 1M" AS metric_value
FROM prices_jan.prices_jan_freq;

```

Sample Raw Data

1. Primary Dataset

This table contains the raw electricity pricing data for each 15-minute interval throughout the month, sourced directly from ERCOT. It serves as the foundation for all subsequent tables.

Table Name: prices_jan.prices_jan_table (*Schema:prices_jan, Table: prices_jan_table*)

	Delivery Date date	Delivery Hour integer	Delivery Interval integer	Settlement Point Name text	Settlement Point Type text	Settlement Point Price numeric	Delivery Timestamp timestamp without time zone
1	2024-01-01	4	3	LZ_WEST	LZEW	17.97	2024-01-01 03:30:00
2	2024-01-01	4	4	LZ_WEST	LZEW	18.24	2024-01-01 03:45:00
3	2024-01-01	5	1	LZ_WEST	LZEW	20.50	2024-01-01 04:00:00
4	2024-01-01	5	2	LZ_WEST	LZEW	19.49	2024-01-01 04:15:00
5	2024-01-01	5	3	LZ_WEST	LZEW	20.79	2024-01-01 04:30:00
6	2024-01-01	5	4	LZ_WEST	LZEW	21.85	2024-01-01 04:45:00
7	2024-01-01	6	1	LZ_WEST	LZEW	24.28	2024-01-01 05:00:00
8	2024-01-01	6	2	LZ_WEST	LZEW	21.80	2024-01-01 05:15:00
9	2024-01-01	6	3	LZ_WEST	LZEW	22.08	2024-01-01 05:30:00
10	2024-01-01	6	4	LZ_WEST	LZEW	21.72	2024-01-01 05:45:00
11	2024-01-01	7	1	LZ_WEST	LZEW	27.57	2024-01-01 06:00:00
12	2024-01-01	7	2	LZ_WEST	LZEW	26.63	2024-01-01 06:15:00
13	2024-01-01	7	3	LZ_WEST	LZEW	24.94	2024-01-01 06:30:00
14	2024-01-01	7	4	LZ_WEST	LZEW	26.32	2024-01-01 06:45:00
15	2024-01-01	8	1	LZ_WEST	LZEW	27.90	2024-01-01 07:00:00
16	2024-01-01	8	2	LZ_WEST	LZEW	30.04	2024-01-01 07:15:00
17	2024-01-01	8	3	LZ_WEST	LZEW	33.91	2024-01-01 07:30:00
18	2024-01-01	8	4	LZ_WEST	LZEW	32.50	2024-01-01 07:45:00
19	2024-01-01	9	1	LZ_WEST	LZEW	68.66	2024-01-01 08:00:00
20	2024-01-01	9	2	LZ_WEST	LZEW	45.06	2024-01-01 08:15:00

2. Frequency Table

This table is derived from the primary dataset and captures the below-breakeven electricity price frequencies for each 15-minute interval of the day. It provides critical insights into periods of profitability during the month.

Table Name: prices_jan.prices_jan_freq (*Schema:prices_jan, Table: prices_jan_freq*)

	Hour of Day numeric	Minute of Hour numeric	Below Breakeven YTD bigint	Below Breakeven 6M bigint	Below Breakeven 1M bigint	Time of Day time without time zone
1	0	0	1	1	1	00:00:00
2	0	15	1	1	1	00:15:00
3	0	30	1	1	1	00:30:00
4	0	45	1	1	1	00:45:00
5	1	0	1	1	1	01:00:00
6	1	15	1	1	1	01:15:00
7	1	30	1	1	1	01:30:00
8	1	45	1	1	1	01:45:00
9	2	0	1	1	1	02:00:00
10	2	15	1	1	1	02:15:00

3. Aggregated Electricity Price Table

This table houses the average Settlement Point Price for each 15-minute interval throughout the month. It is a summarized version of the primary dataset, making it easier to analyze trends and averages.

Table Name: prices_jan.prices_jan_aggregated (*Schema:prices_jan, Table: prices_jan_aggregated*)

	hour_of_day numeric	minute_of_hour numeric	avg_price numeric	time_of_day time without time zone
1	0	0	38.8141935483870968	00:00:00
2	0	15	35.9458064516129032	00:15:00
3	0	30	38.7677419354838710	00:30:00
4	0	45	41.1074193548387097	00:45:00
5	1	0	44.5219354838709677	01:00:00
6	1	15	39.1712903225806452	01:15:00
7	1	30	36.3519354838709677	01:30:00
8	1	45	41.0351612903225806	01:45:00
9	2	0	43.9325806451612903	02:00:00
10	2	15	36.1470967741935484	02:15:00

4. Unpivoted Frequency Data Table

This long-table format of the frequency data table was transformed from the original wide-table format. It is tailored for generating Tableau worksheets accurately and efficiently.

Table Name: prices_jan.prices_jan_unpivoted (*Schema:prices_jan, Table: prices_jan_unpivoted*)

	Time of Day time without time zone 	metric_type 	metric_value 
85	21:00:00	YTD	2
86	21:15:00	YTD	2
87	21:30:00	YTD	1
88	21:45:00	YTD	1
89	22:00:00	YTD	1
90	22:15:00	YTD	1
91	22:30:00	YTD	1
92	22:45:00	YTD	2
93	23:00:00	YTD	2
94	23:15:00	YTD	1
95	23:30:00	YTD	1
96	23:45:00	YTD	2
97	00:00:00	6M	1
98	00:15:00	6M	1
99	00:30:00	6M	1
100	00:45:00	6M	1
101	01:00:00	6M	1
102	01:15:00	6M	1
103	01:30:00	6M	1
104	01:45:00	6M	1
105	02:00:00	6M	1

Data Cleaning, Manipulation, and Methodology

The initial datasets retrieved from ERCOT, CoinMarketCap, and Blockchain.com required extensive cleaning, manipulation, and formatting to ensure compatibility and seamless transitions between tools, including Google Sheets, PostgreSQL, and Tableau.

Dummy Key Integration:

To establish relationships between the primary dataset and secondary tables, dummy keys were introduced into the Settlement Point Data. These keys, initialized with a numerical value of 1, acted as primary and foreign keys, facilitating links between tables like Frequency and Aggregated tables.

Mean and Median price calculation:

The raw Settlement Point Prices, recorded at 15-minute intervals, exhibited significant skewness due to occasional extreme surges exceeding thousands of dollars per kWh. To mitigate this, aggregated tables were created for each month and the entire year. These tables grouped settlement point prices for the same 15-minute intervals across all days within a period (e.g., prices for 12:00 PM–12:15 PM across ~30 days in a month). This aggregation provided a clearer picture of 24-hour patterns and allowed for more reliable and actionable insights.

Table type conversion:

All of the raw data came in the form of wide tables which is easier for the human eye to process but is not the conventional format for the tools utilized in this study. In addition, Tableau is limited to only dual-axis graphs and with this study incorporating 3 breakeven lines calculated over 3 different timeframes. It was going to be impossible to simultaneously show the 3 different metric types on one graph without conversion of the tables to long-table format, allowing for multi-dimensional visualizations.

Tableau Parameters and Calculated Fields:

Interactive and dynamic visualizations in Tableau were made possible using Parameters and Calculated Fields. Parameters were used to define constant breakeven price points, while Calculated Fields and Tableau's VizQL language enabled advanced functionalities such as color-coded line graphs, conditional formatting based on profitability, and the creation of additional dimensions and measures.

Profitability Rate calculation:

The Profitability Rate was calculated using the frequencies of below-breakeven electricity prices within specific intervals, divided by the total number of 15-minute intervals in the corresponding period. This straightforward calculation leveraged SQL functions like EXTRACT() and COUNT() for accuracy and scalability. Its simplicity ensured versatility and minimized the potential for errors.

Tools and Technologies

This section outlines the key tools and technologies used throughout the analysis, detailing their specific roles and contributions to achieving the study's objectives.

PostgreSQL(Version 17.2)

PostgreSQL acted as the primary database management system in this study, handling the storage, cleaning, querying and datasets manipulation. Its reliability, efficiency, versatility, and high-performance computational power made it the ideal choice for managing complex data workflows. Key features utilized include:

- Comprehensive and Customizable Servers, Schemas, and Tables: Facilitated the clean storage of data and creation of additional Schemas and Tables.
- Built-in Advanced Query Functions: Functions like PERCENTILE_CONT() and EXTRACT() allowed for extraction of detailed and complex data with a single query.

Tableau Desktop(2024.3.1 - Professional Edition)

Tableau from Salesforce was used to create interactive visualizations and worksheets, offering a clear and accurate representation of complex datasets. For instance, the “Average Yearly Prices per 15-Minute Interval” line graph visualized nearly 35,000 rows of data with ease. Key Tableau features include:

- Parameters: Enabled customized Breakeven Price Point reference lines for deeper insights.
- Calculated Fields & VizQL: Allowed for creation of conditionals such as “Profitability” to directly highlight the profitable periods.
- Color-coded Line graphs: Illustrated trends and patterns in settlement point prices across months, making the insights visually intuitive.

Google Sheets(Web-based Spreadsheet Application)

Google Sheets played a crucial role in the early-stage cleaning and formatting of data to meet PostgreSQL’s strict requirements. It was also invaluable for creating auxiliary tables such as monthly profitability summaries and yearly network hash rate data. Frequently utilized features include:

- Filters: Allowed for the exclusive compilation of Western Texas Load Zone only data.
- Data Cleaning Functions: Functions like SUBSTITUTE(), VLOOKUP(), FIND(), and IF() streamlined the preprocessing of raw data.
- Data Manipulation and Statistical Functions: Functions such as ROUNDUP(), AVERAGE(), STDEV(), SUM() supported the creation of auxiliary tables for quick reference and analysis.

References

Data Sources:

- [ERCOT Data Product Details](#): Yearly Settlement Point Price Data for the Western Texas Load Zone, including 15-minute interval records.
- [Coin Market Cap](#): Aggregated daily Bitcoin price data for market analysis.
- [Blockchain.com](#): Comprehensive daily network hash rate data for Bitcoin mining operations.

Tools & Technologies:

- PostgreSQL (Version 17.2): [Official Webpage](#)
- Tableau Desktop (Version 2024.3.1 Professional Edition): [Official Webpage](#)
- Google Sheets: [Google Workspace Official Webpage](#)

External Documentation and Support:

- [PostgreSQL Handbook and Manuals](#)
- [Tableau Guidebook](#)
- [Google Sheets Functions List](#)