Electricity Market Analysis Report

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ABSTRACT

This paper uses a dataset derived from several European electric power market resources, covering 2017 to 2023, to study the elements affecting electricity spot prices in Southern Norway. Along with local variables like temperature, precipitation, wind power, and reservoir levels, it looks at the price of coal, oil, and gas. Statistical approaches like correlation analysis and time-series evaluations are used to investigate five important business concerns. The results show that gas and electricity costs are significantly correlated. It also indicates that wind generation is becoming more and more influential, and that local electricity prices are more impacted by worldwide markets.

1 INTRODUCTION

Norway has been using electricity since 1892 during the industrial revolution[Endresen 1992]. The country has abundant waterfalls and rivers were first harnessed with waterwheels and other water infrastructures that laid the foundation of a robust hydropower system and helped industries grow. It has become a reliable energy partner of the European Union, especially through supplying global oil and gas [Arellano 2024]. Energy exchanges with other European countries rely on Norway's national electrical grid, managed by Statnett, the country's power system operator. Statnett is responsible for balancing energy consumption and production and provides grid stabilization to make sure that the power supply is always reliable [Statnett 2025]. In Norway, the electricity market follows clear and strict rules that keep grid operations and energy trading separate [EnergiFaktaNorge 2025]. These regulations prohibit trading companies from influencing how the grid is managed. It keeps the market fair and enables Statnett to fairly distribute transmissions and its capacity.

Norway's electricity consumption has ranged between 15,000 and 18,000 MWh per year. The production typically surpass the demand. This ensures stable power supply. However, annual fluctuations in energy balance can still impact market conditions, and makes electricity prices more sensitive to external factors. Additionally, because Norway is part of the broader European energy market, electricity prices are also influenced by regional trade and supply dynamics.

As the first multinational power exchange, Nord Pool was founded in 1993. It guides electricity trading across Europe among participating nations [Nordpool 2025b]. Norway's energy prices have become increasingly volatile due to fluctuating supply and demand. It has been impacted by geopolitical tensions because of the importance of adapting quickly to renewable energy sources. Generating wind power and reservoir levels have all been affected by climate change and erratic weather patterns [Endresen 1992]. For policymakers, energy producers, and industries with high energy use, accurate electricity price forecasting is essential for cost optimization and risk management.

Five important business questions are examined in this report as it examines changes in Southern Norway's electricity prices. The purpose of this study is to determine the main variables influencing changes in electricity prices in Southern Norway.

1.1 Data Description

This dataset captures time-series data from the Southern Norwegian electricity market between 2017 and 2023, comprising 54,264 entries across 20 variables. No sub-sampling was performed. All entries were retained to get a comprehensive view of the electricity market.

To gain an initial understanding of the dataset, we conducted descriptive statistical analysis on key variables. This analysis helps identify trends, variability, and potential outliers before proceeding with further statistical tests.

The Table 1 presents mean, standard deviation, minimum, and maximum values for Electricity spot price and Gas price, providing an initial overview of the dataset's distribution. Energy is measured in different units. It depends on the energy type and how they are traded. Megawatt-hour (MWh) unit is the measurement used for electricity [Statnett 2025]. The price of electricity is usually given in euros per megawatt-hour (EUR/MWh). Oil is stored and traded in barrels (bbl), [EIA 2025]. Oil prices are measured in euros per barrel (EUR/bbl). Coal is a solid fuel, so it is measured by weight in ton (t) [CoalPrice 2025]. Natural gas and water in reservoirs are fluids and it is measured in cubic meters (m^3), [Nordpool 2025a]. These units are used in this dataset.

1.2 Descriptive Statistics Table

Metric	Mean	Std Dev	Min	Max
Electricity Actual Price (EUR/MWh)	75.41	86.04	-61.84	844.00
Electricity Spot Price (EUR/MWh)	57.51	62.89	-29.90	706.87
Gas Price (EUR/MWh)	44.23	48.40	3.51	339.20
Oil Price (EUR/barrel)	64.12	20.10	8.40	123.39
Coal Price (EUR/ton)	111.77	84.99	35.02	402.65
Reservoir Level (million m^3)	21.46	5.93	6.33	33.39
Consumption (MWh)	15,390.75	3,205.19	9,217	25,230
Production (MWh)	16,935.79	4,143.32	6,087	28,293
Wind Generation (MWh)	386.79	339.49	0.00	1,448
Temperature (°C)	8.05	5.99	-12.00	31.00
Precipitation (mm)	0.18	0.63	0.00	14.80
Electrical Load (MW)	4,144.29	763.63	1,595	8,700

Table 1: Descriptive Statistics of Electricity Market Variables

Table 1 shows the electricity market variables. Electricity prices show high volatility, with a standard deviation of 86.04 EUR/MWh. It also shows how electricity prices can drop as low as -29.90 EUR/MWh, creating market imbalance. Gas and coal prices fluctuate significantly. It may indicate a strong link between global energy markets and electricity prices in Norway. Nevertheless, reservoir levels remain stable, but further analysis is needed to see the correlation on electricity prices. Wind power varies widely with a standard deviation of 339.40 MWh. It shows intermittent nature of renewable energy sources. These findings provide a foundation for further analysis.

1.3 Pre-Processing Data

The dataset was inspected for missing values and duplications. It ensured that the data was comprehensive and reliable, particularly for critical variables such as gas prices, reservoir levels, and electricity spot prices. However, discrepancies were found in the time-related columns, where some entries appeared in inconsistent formats. Variables like hour, day, month, year, week, and day of the week contained non-integer or non-numeric entries. These inconsistencies were addressed by filtering out invalid data and transforming the relevant variables into accurate numeric formats.

Electricity prices and energy productions had outliers. However, these extreme values were not removed because price spikes and fluctuations are important for this analysis. Since this study looks at how global commodity prices, weather conditions, and market changes affect electricity prices, keeping all data points helps understand the full range of market behavior.

Although some of these extreme values might seem like errors, they are likely real events in the energy market. Removing them could hide important trends, so all values were kept to maintain a complete picture of price movements.

To better understand the dataset, Pandas Profiling was used to check for data issues and patterns. This analysis found strong correlations between coal prices and other factors. It suggests they may be linked. Additionally, it showed that 79% of precipitation values were zero. It might mean that the dataset lacks enough rainfall values to fully explain its effect on electricity prices.

2 METHODOLOGY

The primary goal of this study is to explore how economic, market, and environmental factors affect electricity spot prices. Since our questions focus on detecting linear relationships, we use Pearson correlation:

$$r = \frac{N\sum xy - \sum x \sum y}{\sqrt{\left(N\sum x^2 - (\sum x)^2\right)\left(N\sum y^2 - (\sum y)^2\right)}}$$

This formula captures both the strength and direction of each factor's connection to electricity prices. We also run t-tests to see whether electricity prices differ significantly before and after 2020, and rely on p-values (with a 5% significance threshold, $\alpha = 0.05$) to confirm these findings. In addition, we use descriptive statistics to understand each variable's basic distributional properties, and a correlation matrix to visualize how these factors interrelate. Spearman and Kendall correlations are better suited for nonlinear and ranked data. Since the analysis focuses on linear relationships, the Pearson correlation is used. Additionally, we do not report an R^2 value, as our goal is to examine correlation strength rather than predictive accuracy.

3 DATA ANALYSIS

To better understand electricity market dynamics, Table 2 summarizes the yearly average of electricity consumption and production in Norway from 2017 to 2023. These figures highlight fluctuations in energy supply and demand. They are important in determining electricity price trends.

Year	Consumption (MWh)	Production (MWh)
2017	17,888.41	19,176.70
2018	15,460.78	16,628.90
2019	15,011.03	15,225.12
2020	15,124.34	17,455.57
2021	15,857.57	17,860.70
2022	15,019.40	16,449.89
2023	15,352.63	17,380.95

Table 2: Average yearly energy consumption and production in Norway, 2017–2023.

To figure out which factors have the greatest impact on electricity prices, we calculated Pearson correlation coefficients for five important variables:

- gas price
- reservoir levels
- wind power
- temperature
- precipitation
- dollar price

Figure 1 shows a bar chart of these correlations. Bars above the zero line, such as gas price, wind and dollar price means that when these factors go up, electricity prices also increase. Negative values below zero means that lower values of these factors are linked to lower electricity prices.

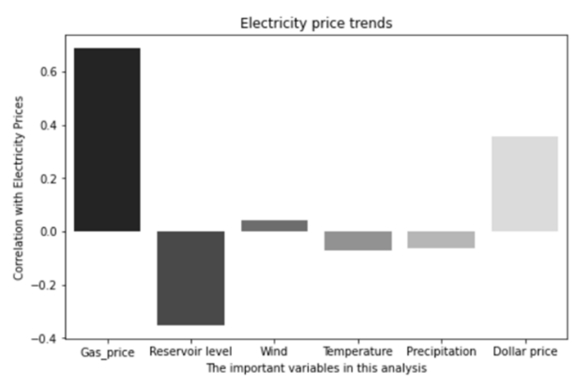

Figure 1: Electricity price trend

The correlation matrix provides a visual representation of the relationships between key variables and how it affects electricity prices. Gas, coal and oil have stronger impacts than temperature and precipitation.

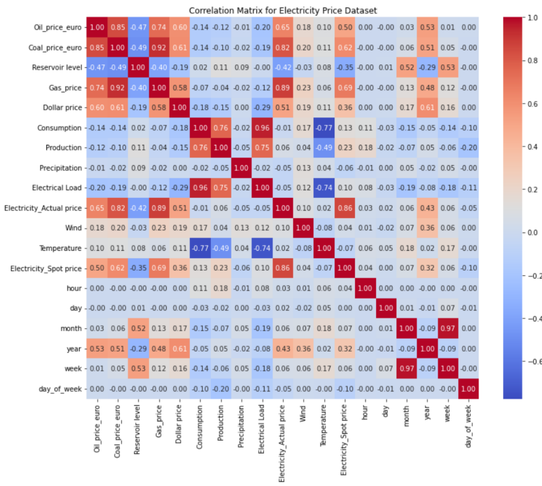

Figure 2: Correlation Matrix of Electricity Price Dataset

Pandas profiling indicated that Coal price euro is strongly correlated with other commodity fields. As illustrated in Figure 2, the correlation matrix indicates overlapping influences in the market.

Correlation	Interpretation
Gas prices & electricity spot prices (0.74)	Strong correlation; higher gas prices lead to higher electricity prices.
Coal prices & electricity actual prices (0.82)	Strong correlation; coal markets significantly influence actual electricity prices.
Reservoir levels (-0.35) & electricity spot prices	Negative correlation; higher hydropower availability helps stabilize prices.
Wind power (0.18) & electricity prices	Weaker correlation; wind power has a growing but still moderate impact.
Precipitation (-0.02) & time-based factors	Little to no impact; economic and market forces are more influential.

Table 3: Correlation between electricity prices and key variables.

These insights form the basis of our subsequent analysis, where we will explore in the business questions related to electricity price fluctuations in Southern Norway.

3.1 Question 1: How do gas prices and electricity spot prices in Southern Norway relate during high and low reservoir levels?

Scatter plots are used to analyze how gas prices and electricity spot prices vary in relation to reservoir levels.

For low reservoir levels, it is defined below the 25th percentile. The red trend line indicates a clear positive relationship, so when gas prices increase, the higher the electricity spot prices. The correlation of 0.66 shows the strong correlation between gas and electricity prices.

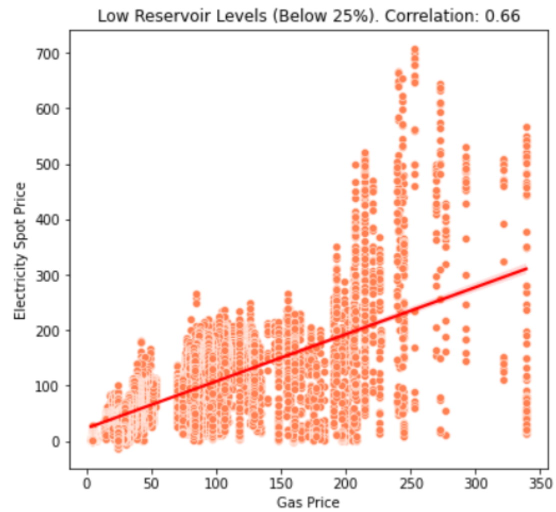

Figure 3: Low Reservoir Level

When reservoir levels are high, hydropower effectively mitigates reliance on gas. Figure 4 shows that it is a weaker correlation (0.44) between gas prices and electricity spot prices.

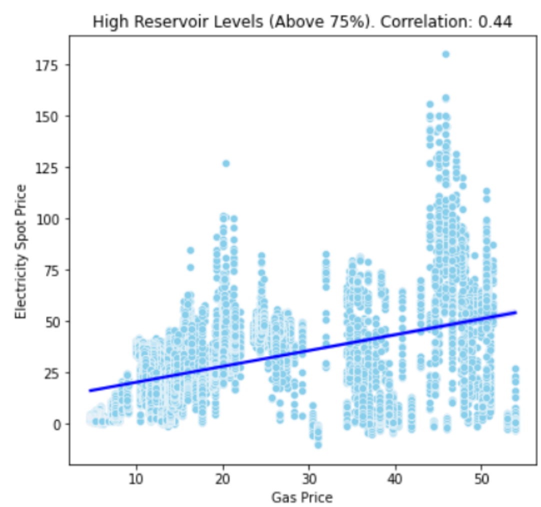

Figure 4: High Reservoir Level

3.2 Question 2: Has the relationship between wind power generation and electricity spot prices in Southern Norway grown stronger compared to rainfall over the past three years?

To compare the influence of windpower and rainfall on electricity prices, correlations from 2021 to 2023 have been examined.

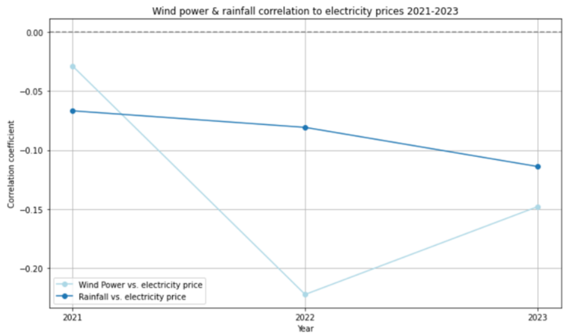

Figure 5: Win power and rainfall correlation to electricity prices

Figure 5 shows that over the past three years, the relationship between wind power generation and electricity spot prices in Southern Norway has strengthened, compared to the relationship between rainfall and electricity prices.

In 2022, the wind power had a strong negative correlation than rainfall. Even if the correlation has increased slightly in 2023, the wind power had a greater effect on electricity prices than rainfall.

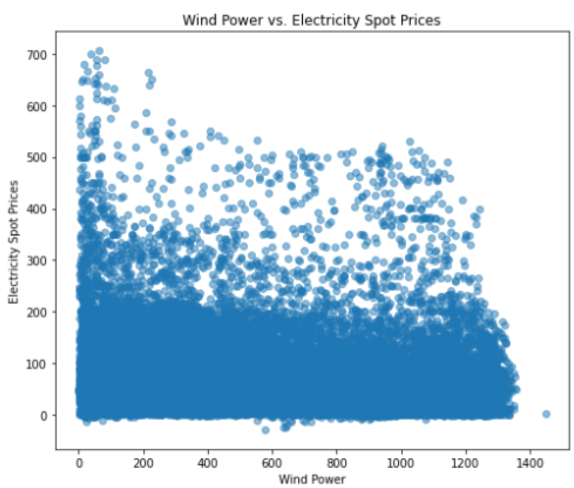

Figure 6: Wind power vs electricity prices

To further assess whether wind power's influence on electricity prices has grown stronger over time, additional analysis was conducted. The scatter plots in Figures 7 and 8 consistently indicate that wind power has shown a stronger correlation with electricity prices compared to rainfall. These combined visualizations reinforce the statistical findings:

- Wind Power vs. Electricity Spot Price (2021-2023): -0.0896
- Precipitation vs. Electricity Spot Price (2021-2023): -0.0685

These results indicate that while wind power has gained influence on electricity price, its effect remains relatively moderate. However, as wind power continues to expand, its impact on electricity prices may become more significant in the future.

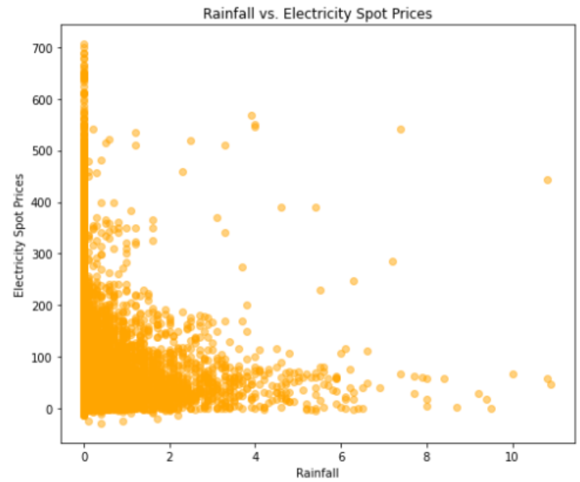

Figure 7: Rainfall vs electricity prices

3.3 Question 3: Are extreme electricity price spikes in the Southern Norwegian market more strongly related to global commodity price changes (such as oil, gas, and coal) or local factors like reservoir levels and temperature?

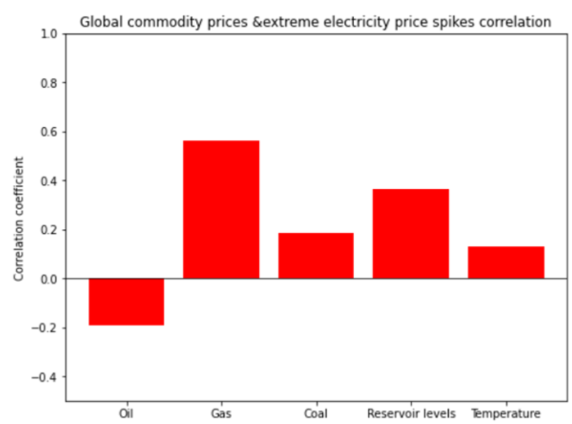

Figure 8: Global commodity and extreme price spikes correlation

This bar chart in Figure 8 shows how global commodity prices and local factors influence extreme electricity price spikes. It focuses on the top 5% of extreme price events.

Gas prices have the strongest positive correlation (0.56). When gas prices rises, extreme electricity prices also increase. Coal has a weaker positive correlation (0.18). The negative correlation (-0.19) is oil, because Norway is producing less for electricity production.

In contrast, local factors like reservoir levels (0.36) and temperature (0.13) show weaker correlations, suggesting that global commodity markets, especially gas, have a greater impact on extreme electricity price spikes than local conditions.

3.4 Question 4: Has the relationship between electricity spot prices and actual electricity prices in Southern Norway changed significantly from before 2020 to during and after 2020? If so, does this change mean that the spot market is becoming more or less reliable for predicting the final prices that consumers pay?

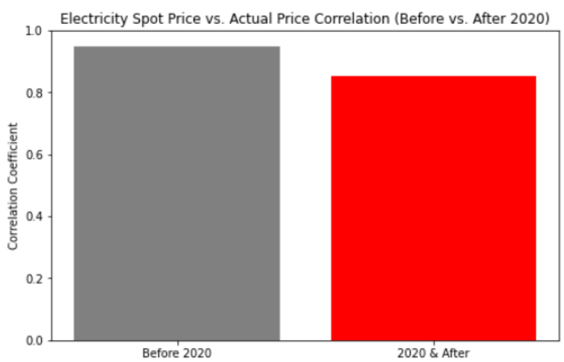

Figure 9: Electricity Spot Price vs. Actual Price Correlation, before and after 2020)

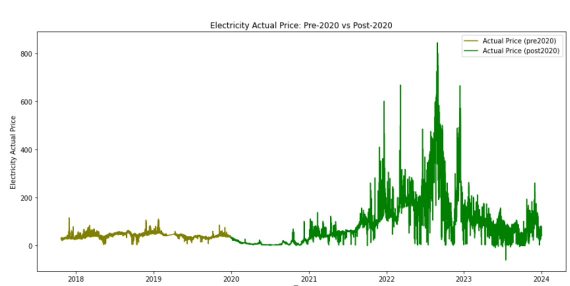

Figure 10: Electricity Actual Price, before and after 2020)

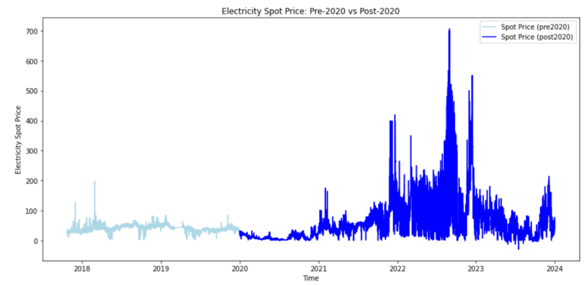

Figure 11: Electricity Spot Price, before and after 2020)

The relationship between electricity spot prices and actual prices weakened after 2020 as shown in figure 9, meaning the spot market became less reliable in predicting final consumer prices.

A t-test compared electricity prices before and after 2020:

- Electricity Spot Price: T-statistic = -62.75, P-value = 0.00000
- Electricity Actual Price: T-test = -98.09, P-value = 0.00000

Since both p-values are 0.00, this confirm a statistically significant difference. Figures 10 and 11 shows that price volatility increases significantly after 2020. This makes actual prices harder to predict based on spot prices.

The findings indicate a major shift in electricity pricing behavior after 2020, which may be influenced by external market changes. This makes it harder to predict electricity prices and how much consumers pay.

3.5 Question 5: Which has a stronger influence on Southern Norwegian electricity spot prices: the dollar prices or local weather factors like temperature and precipitation?

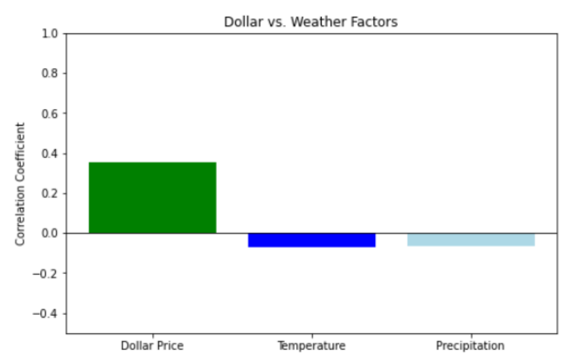

Figure 12: Influence on electricity spot prices

The analysis shows that dollar prices have a stronger influence on electricity spot prices than local weather factors. The correlation between dollar prices and electricity spot prices is 0.36 ($p < 0.001$). Temperature (-0.07) and precipitation (-0.06) have much weaker correlations, shown in Figure 12. It indicates that global market factors, such as currency fluctuations, play a larger role in shaping electricity prices in Southern Norway. Meanwhile, the weak correlations for temperature and precipitation suggest that local weather conditions have little direct impact on electricity price fluctuations compared to financial market influences.

3.6 Discussion of Results

The findings confirm that Norwegian electricity prices are primarily driven by global market factors rather than local weather conditions. Gas prices play a dominant role in price fluctuations. Hydropower remains a stabilizing force, but its effectiveness depends on reservoir levels. Wind power is becoming increasingly relevant. Price votality has increased since 2020 and this makes prices in electricity harder to predict. Below, each questions gets discussed from the analysis.

3.6.1 The influence of gas prices and reservoir levels. The relationship between gas prices and electricity spot prices depends on reservoir levels. When reservoir levels are low, Norway relies more on gas-powered electricity. This makes the prices more sensitive to gas price fluctuations. The correlation observed is very strong during periods of low hydropower availability. When the reservoirs are full, the electricity supply remains stable. This limits price fluctuations because dependency on gas is reduced. This confirms that effective hydropower management plays a crucial role in maintaining price stability.

3.6.2 Growing influence of wind power. From 2021 to 2023 wind power generation has shown a stronger relationship with electricity prices compared to rainfall. The results reveal that when wind power production is high, electricity prices tend to decrease. In contrast, precipitation levels have little effect on pricing. It indicates that wind power is becoming more significant in the electricity market. Since weather is unpredictable, wind power trend remains uncertain. This makes it essential to enhance grid flexibility in Norway, and invest in other types of energy solutions that can better integrate wind power into the electricity system.

3.6.3 Extreme electricity price spikes. It is closely linked to global commodity prices, particularly gas, than to local factors such as temperature or reservoir levels. The analysis shows that when gas prices increases, electricity prices goes up as well. This is specifically during periods of low hydropower. In a lesser extent, coal prices also contribute to price changes. Oil prices show little direct impact. This highlights the dependence on global energy markets in Norway, where disruptions in gas supply can cause sudden price swings. Given this sensitivity, reducing reliance on gas through better hydropower and wind integration could help mitigate extreme price fluctuations.

3.6.4 Price Volatility Increases after 2020. The relationship between electricity spot prices and actual consumer prices weakened after 2020. Correlation declined from 0.90 to 0.80. Statistical analysis confirms this shift, with t-test results indicating the significant change. Increased volatility in electricity prices suggests that spot prices are now a less reliable predictor of what consumers ultimately pay. This shift may be influenced by global energy market disruptions and can change energy policies in Norway. The effects of the economy after COVID-19, altered electricity demand patterns [Gilbert 2021]. As a result, forecasting electricity prices has become more challenging. It requires a comprehensive approach that considers external factors beyond just spot prices.

3.6.5 Global financial market vs Local weather factors. The correlation analysis shows that when dollar prices changes, it affects electricity prices. Temperature and rainfall have only weak correlations. The dollar rate impacts energy imports, exports, and overall market stability. It is also crucial to monitor currency trends that could provide better insight, to predict electricity prices.

4 CONCLUSION

This study investigated the factors influencing electricity spot prices in Southern Norway using dataset from various European electricity markets from 2017 to 2023. By applying descriptive analysis, Pearson correlation, and statistical testing, we examined the relationships between these factors and electricity prices. The findings confirm that global market forces, especially gas prices and currency fluctuations, have the strongest influence on electricity prices in Southern Norway. Hydropower helps stabilize prices when reservoir levels are high, while wind power is becoming more important as it adds variability. Electricity prices are becoming more volatile and global markets also play a huge role. Norway should focus on making its grid more flexible and use different energy sources to reduce price volatility. Further research into the impacts of geopolitical and regulatory changes could provide deeper insights to predict electricity price.

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