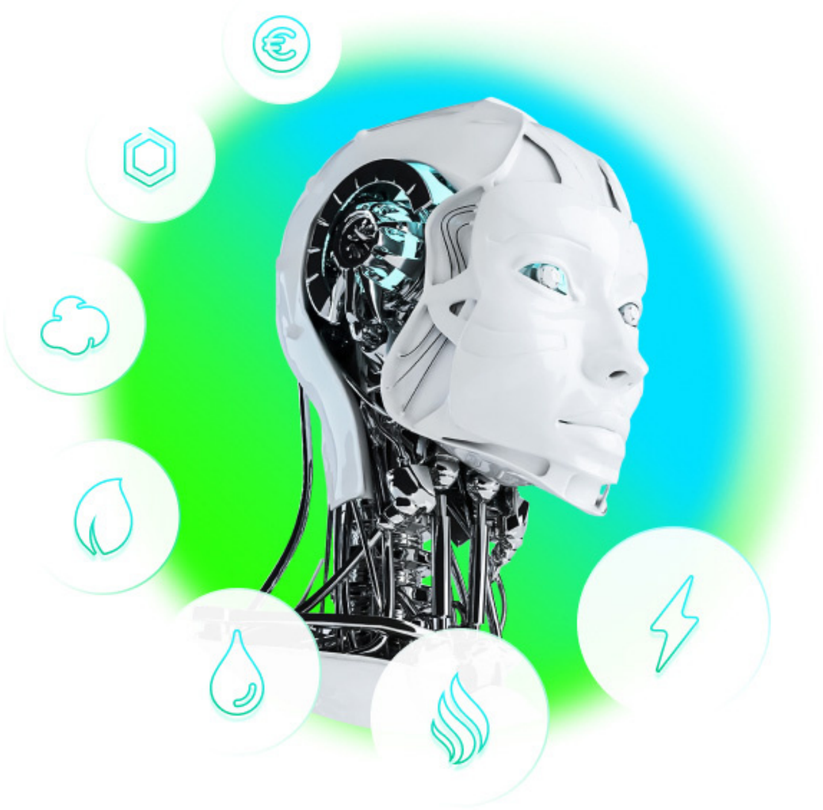


EnergyMarketPrice

# Prophet Solution
# Read Your Own Future

Use the most advance artificial intelligence system on the market to make accurate predictions of Energy Market Prices all other the world.

## Forecasts and the Need for Forecasts.

Forecasting is a science that refers to the process of making predictions about future events based on past and present data. Forecasting is used in various fields, including business, economics, finance, weather, and even sports.

Forecasting provides a framework for decision-making based on the most likely scenarios for the future. By analyzing trends and patterns in historical data, forecasters can identify potential future events and develop models to predict their likelihood and impact. These models can help decision-makers prepare for future events, identify potential risks and opportunities, and allocate resources effectively.

### People use forecasting for a variety of reasons, but some common ones include:

- **Planning:** By making predictions about what may happen, organizations can better prepare for different scenarios and make informed decisions about how to allocate resources, such as time, money, and personnel.
- **Budgeting:** By predicting revenue and expenses for the upcoming period, organizations can create a budget that will help them
- **Risk Management:** Forecasting can be used as a tool to help manage risk. By predicting potential threats or changes, organizations can take steps to mitigate risks and prepare for emergencies.
- **Resource allocation:** Forecasting can also help with resource allocation. By predicting demand or sales, organizations can adjust their production or inventory levels to ensure they have the necessary resources on hand.
- **Decision-making:** Forecasting can also help individuals and organizations make better decisions. By providing insight into what may happen in the future, it can help people make more informed choices and avoid costly mistakes.
- **Competitive advantage:** Forecasts can provide a competitive advantage by enabling individuals and organizations to anticipate and respond to changes in the market. For example, sales forecasts can help businesses identify new market opportunities and adjust their marketing strategies accordingly.

## Forecasting for Energy Markets.

Forecasting is particularly important in energy markets, where accurate predictions of supply and demand are critical for ensuring a reliable and efficient energy system. Energy markets are complex and dynamic, influenced by a wide range of factors such as weather patterns, geopolitical events, technological advancements, and consumer behavior. In the energy market, accurate forecasts can inform pricing and trading strategies, aid in risk management, and improve operational efficiency.

Energy forecasting involves predicting future demand for energy, as well as the supply and prices of energy sources such as oil, gas, and electricity.

- In the short term, energy forecasting is important for managing the day-to-day operations of the energy system, such as balancing supply and demand and ensuring grid stability. Short-term forecasts are typically based on real-time data, such as weather forecasts, energy consumption patterns, and market trends.
- In the medium to long term, energy forecasting is important for planning and investment decisions. This includes forecasting future energy demand and the development of new energy infrastructure such as power plants, transmission lines, and renewable energy sources.
- Long-term forecasts are typically based on trends in population growth, economic development, and technological advancements.

Overall, accurate energy forecasting is critical for ensuring a reliable and efficient energy system, and for supporting informed decision-making by energy companies, policymakers, and investors.

## Techniques Used for Forecasting and Time-series for Energy Markets?

There are various techniques for forecasting energy markets, including econometric models, time-series analysis, and machine learning algorithms. The choice of technique depends on the type of data available, the level of uncertainty, and the complexity of the problem.

Time series forecasting is a technique used to predict future values of a time series based on past observations. In the case of energy market prices, time series forecasting can be used to predict future prices based on historical data.

### There are four general components that a time series forecasting model is comprised of:

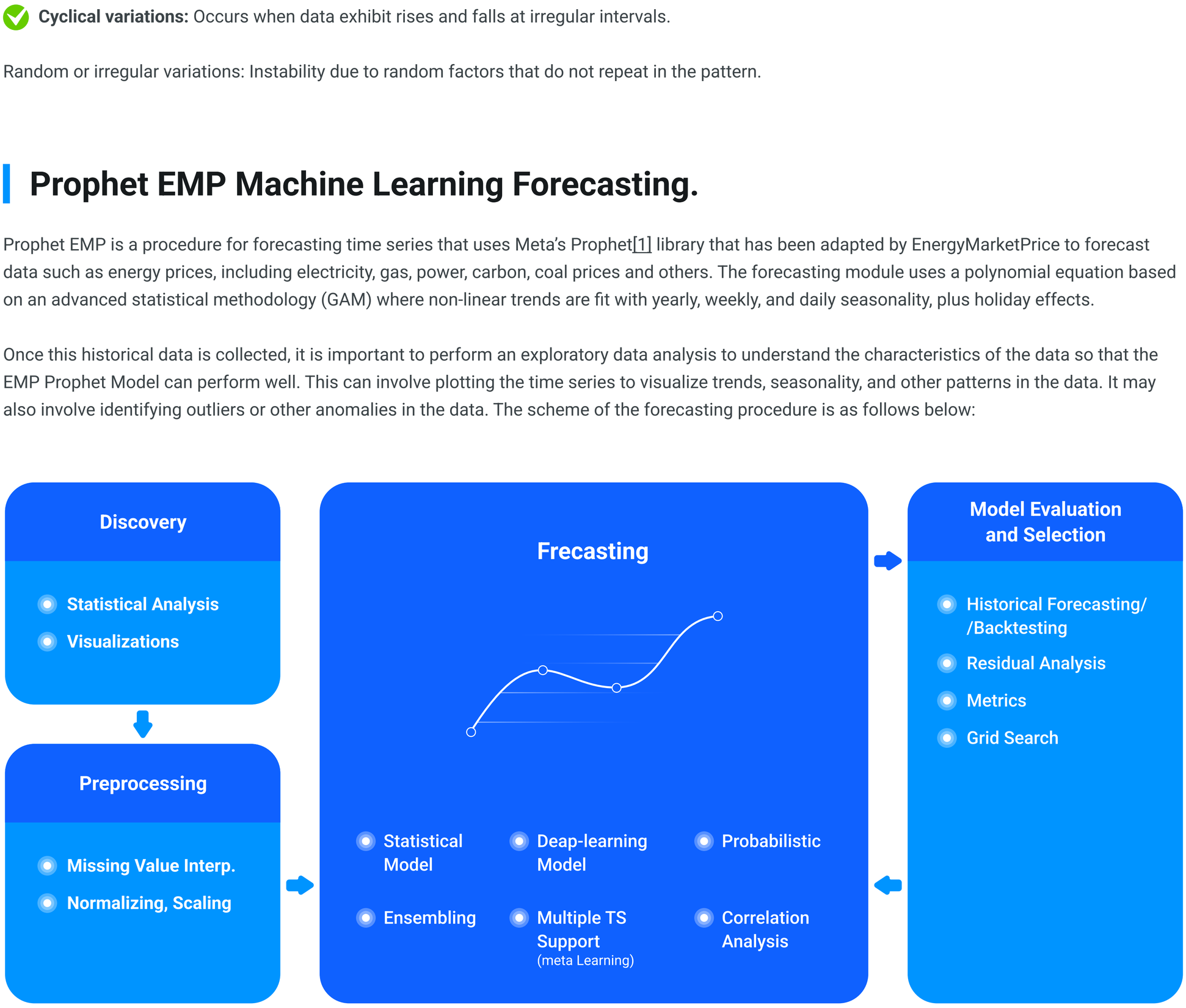
- **Trend:** Increase or decrease in the series of data over longer a period.
- **Seasonality:** Fluctuations in the pattern due to seasonal determinants over a period such as a day, week, month, season.
- **Cyclical variations:** Occurs when data exhibit rises and falls at irregular intervals.

Random or irregular variations: Instability due to random factors that do not repeat in the pattern.

## Prophet EMP Machine Learning Forecasting.

Prophet EMP is a procedure for forecasting time series that uses Meta's Prophet[1] library that has been adapted by EnergyMarketPrice to forecast data such as energy prices, including electricity, gas, power, carbon, coal prices and others. The forecasting module uses a polynomial equation based on an advanced statistical methodology (GAM) where non-linear trends are fit with yearly, weekly, and daily seasonality, plus holiday effects.

Once this historical data is collected, it is important to perform an exploratory data analysis to understand the characteristics of the data so that the EMP Prophet Model can perform well. This can involve plotting the time series to visualize trends, seasonality, and other patterns in the data. It may also involve identifying outliers or other anomalies in the data. The scheme of the forecasting procedure is as follows below:



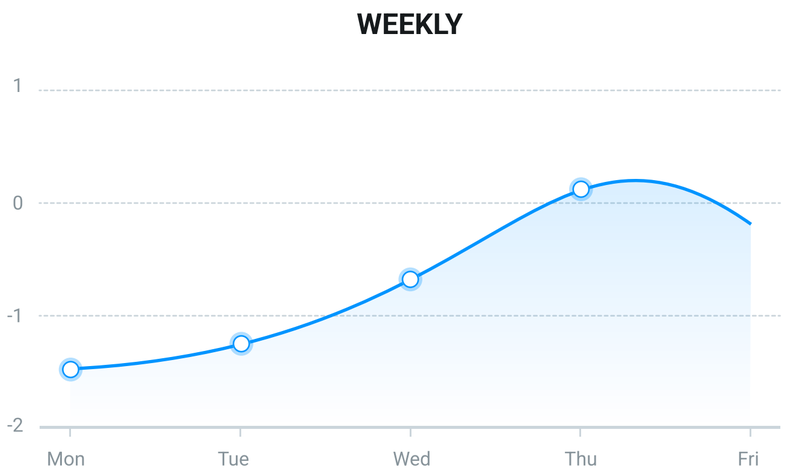

Once a suitable model has been selected, the historical data can be used to train the model, and then the model can be used to make predictions for future energy market prices. It is important to validate the accuracy of the model's predictions using a holdout set of data, and to continually monitor the model's performance over time to ensure it remains accurate and relevant.

The selection of the best model and training of the model are iterative processes that involve multiple rounds of experimentation and optimization until the desired performance is achieved.

[1] See Annex 1 at the end of the document, "What is the methodology of Prophet" for further details about how the model is computed, the equation and parameters involved.

## Why Prophet?

EnergyMarketPrice has chosen Prophet because it is a powerful and flexible algorithm that helps businesses and individuals save time and money by making make accurate predictions about future trends, events, and outcomes. The tool also provides a calendar of values per each month, to show how the behavior of price is shaped each month. It can suggest a potential “buy” and “sell” trigger for the period.




| SELL | BUY |
|---|---|
| THURSDAY | MONDAY |


| SELL | BUY |
|---|---|
| AUGUST | JUNE |

**February 2023**

| | 1 | 2 | 3 | 6 | 7 | 8 | 9 | 10 | 13 | 14 | 15 | 16 | 17 | 20 | 21 | 22 | 23 | 24 | 27 | 28 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forecsted | 163.84 | 164.74 | 164.21 | 163.89 | 164.76 | 166.03 | 167.52 | 167.46 | 167.68 | 168.40 | 169.35 | 170.36 | 169.66 | 167.23 | 166.89 | 166.74 | 166.63 | 164.84 | 159.52 | 158.44 |
| Actual | 169.02 | 161.65 | 164.00 | 159.88 | 154.75 | 148.25 | 148.63 | 152.49 | 147.29 | 147.84 | 151.01 | 149.98 | 147.18 | 147.75 | 142.00 | 142.79 | 142.76 | 142.76 | 141.38 | 135.46 |

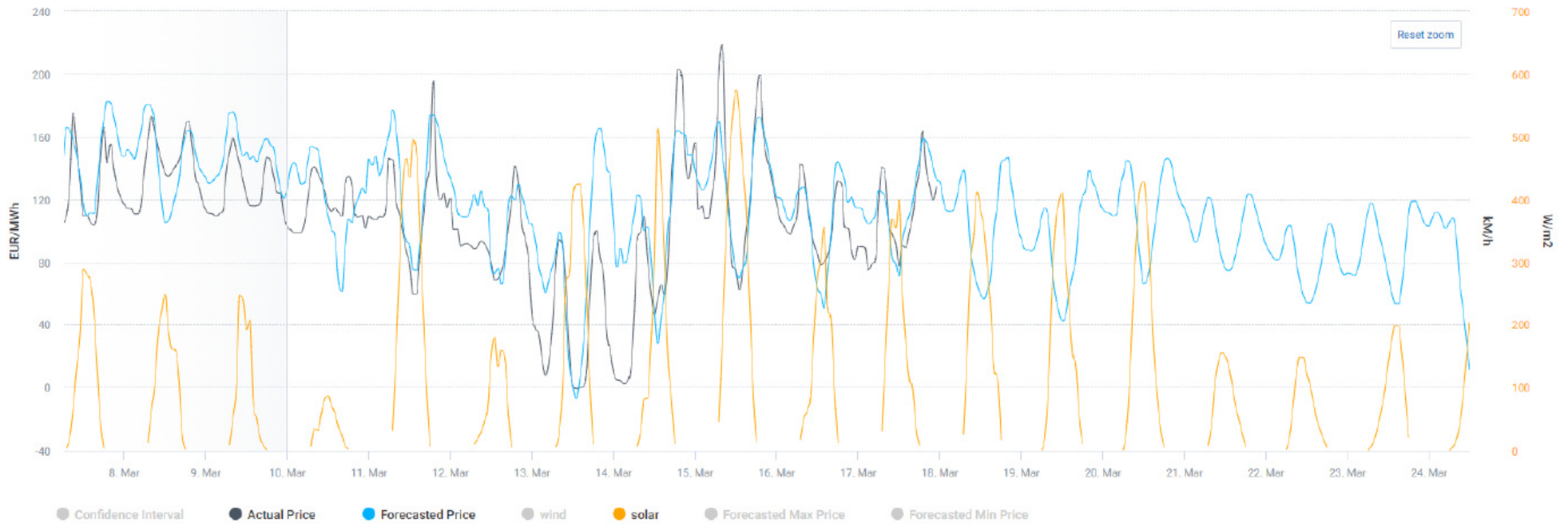
The Date of the Forecast · Neutral Value · Lowest Value · Highest Value

With this model EnergyMarketPrice has made possible for users to access a wide range of forecasting techniques, from simple trend analysis to sophisticated machine learning algorithms, and generate forecasts with high accuracy and reliability. The tool provides several accuracies methodologies (MAPE, RMSE, MSE etc.) that can identify how the forecasts were performing for a specific period.

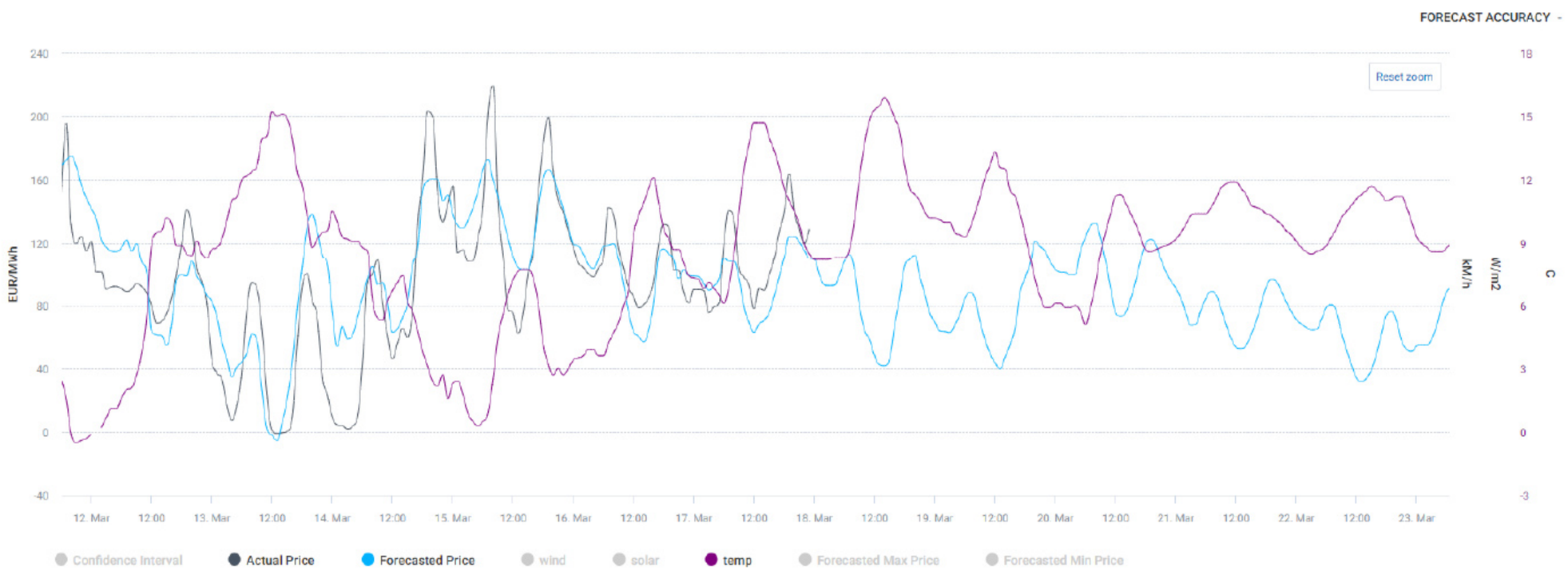
The EMP Prophet Forecasting Tool also adjusts for holidays and other event seasonal events. Prophet includes holidays for more than 130 countries.

It is also possible to add **external regressors, weather factors, carbon, gas, coal included depending** on: the market characteristics, granularity of data, availability of data, forecasting period required, correlation.

**NL Spot Hour Contracts DD — Regressors: wind: (-0.49), solar: (-0.12)**




**NL Spot Hour Contracts DD — Regressors: temp: (-0.44), wind: (-0.49)**




The final EMP Forecasting tool was designed to be user-friendly and easy to use, with intuitive interfaces, and real-time data feeds that allow users to visualize and analyze data in real-time.

As a result, the EMP Forecasting tool is the ultimate solution for anyone looking to make accurate, data-driven decisions and stay ahead of the competition.

# EMP Adjusted Prophet Modelling

**EnergyMarketPrice has adjusted the Prophet Model for various energy related forecasting products including but not limited to:**

- Hourly, Spot and Forward forecasts for Electricity, Gas, Carbon, Oil, Coal
- Spot Hour Forward Curve on Power and Gas: Historical and Prophet Coefficients
- Weather, and other combination of factors included in the model. Drivers such as carbon, gas, coal or meteo parameters
- Continuous markets and expired markets forecasts possibility
- Hourly, Daily, Weekly and Monthly snapshots with results
- Advantage of selecting or combining your own parameters
- Historical and forecast prices sent via API or interface.
- Highest/lowest values over the month
- Trend over the week, month, and Year
- Historical accuracy testing past 10, 20, 60 days
- 14d,1m, 3m, 6m, 9m, 12m, 24m, 36m,50m forecasts
- Optimum scenario pick - EMP discretion
- **Fast adjustment to black swan events: The EMP Prophet Model also adjusts for black swan events, ensuring that users can respond quickly to unexpected changes in the market.**

With its intuitive interface and real-time data feeds, the EMP Prophet Model is the ultimate solution for anyone looking to make data-driven decisions and stay ahead of the competition.

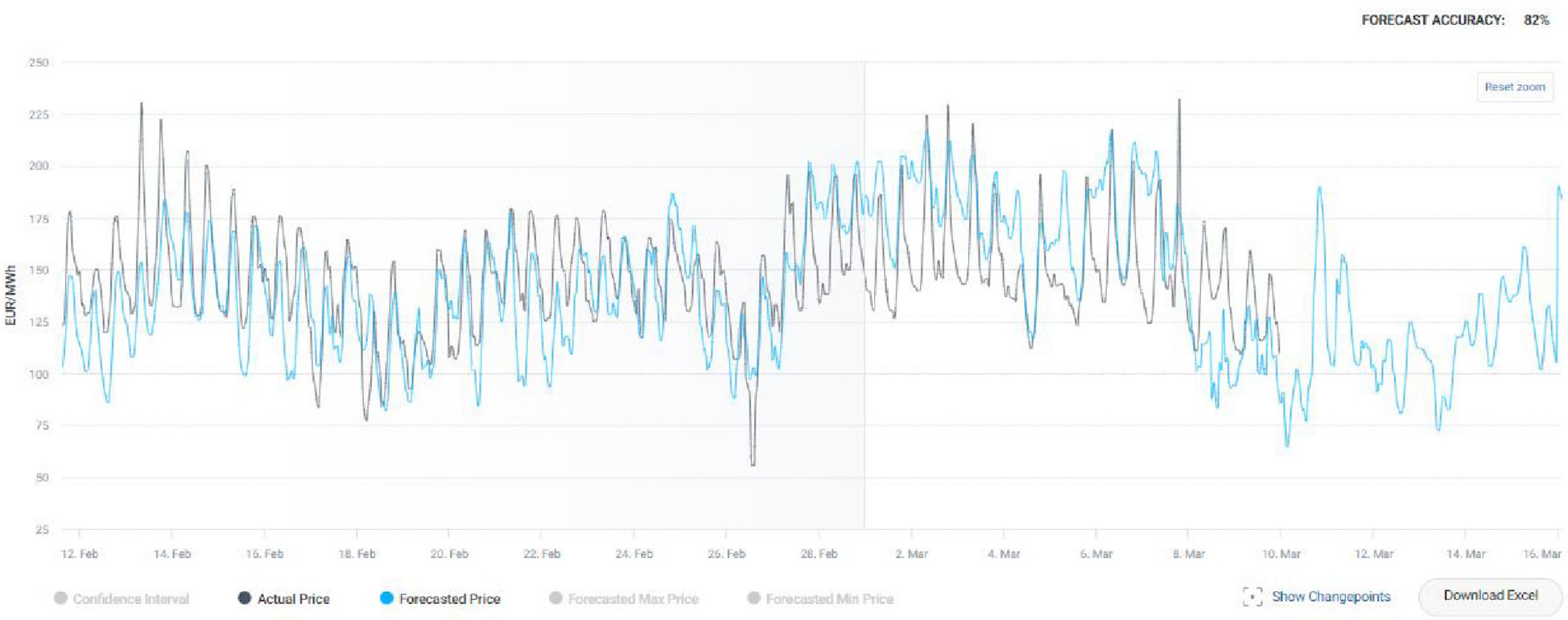
Some of the examples of the clients that EMP has offered the EMP Prophet solution include:

Prophet Results: BritNed Case.

**Forecast of Spreads between UK and NL. Month, Quarters, Years. 1M ahead.**

| Marked Date | Forecasts Days Out | Britned MAPE - Forecasting error, % |
|---|---|---|
| Cal'21 (Feb) | 26 days forecast | 15.9% (13%) |
| Cal'21 (Mar) | 33 days forecast | 21% (1%) |
| May'20 (Feb) | 20 days forecast | 16.6% (8.6%) |
| May'20 (Apr) | 23 days forecast | 3.89% (11%) |
| April'20 (Feb) | 26 days forecast | 3.43% (8%) |
| April'20 (Feb) | 28 days forecast | 14.4% (8%) |
| Q2-20 (Mar) | 33 days forecast | 7.2% (14%) |
| Q3-20 (May) | 51 days forecast | 10.1% (5%) |
| May'20 (Apr) | 23 days forecast | 13.4% (6.5%) |
| Jun'20 (May) | 23 days forecast | 7% (6%) |

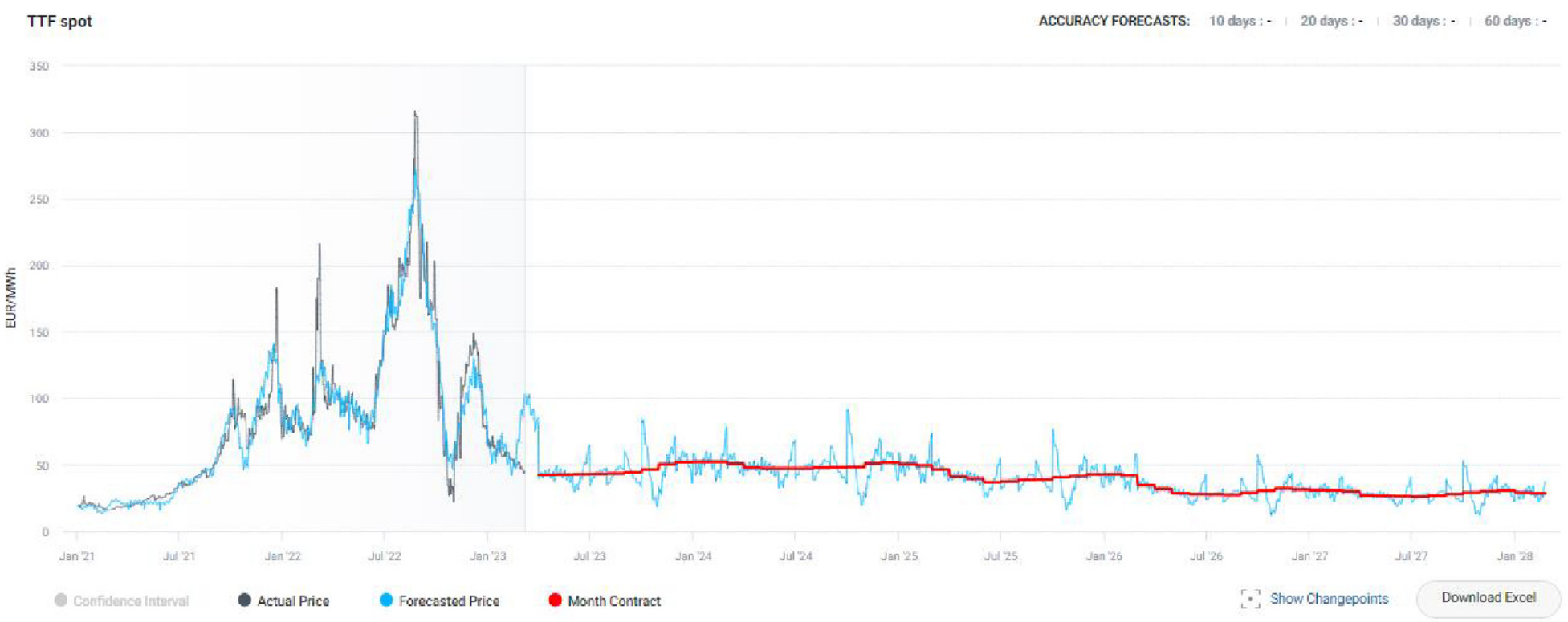

Prophet Results: EMP Prophet Case. Forecasts for 14 D. France Spot Hour DD. Forecast as of March 1st, 2023, for 14 days ahead.




MAINEnergie
part of audax renewables

Prophet Results: MainEnergie Case.

**Forecasts for 36m and 60m.**



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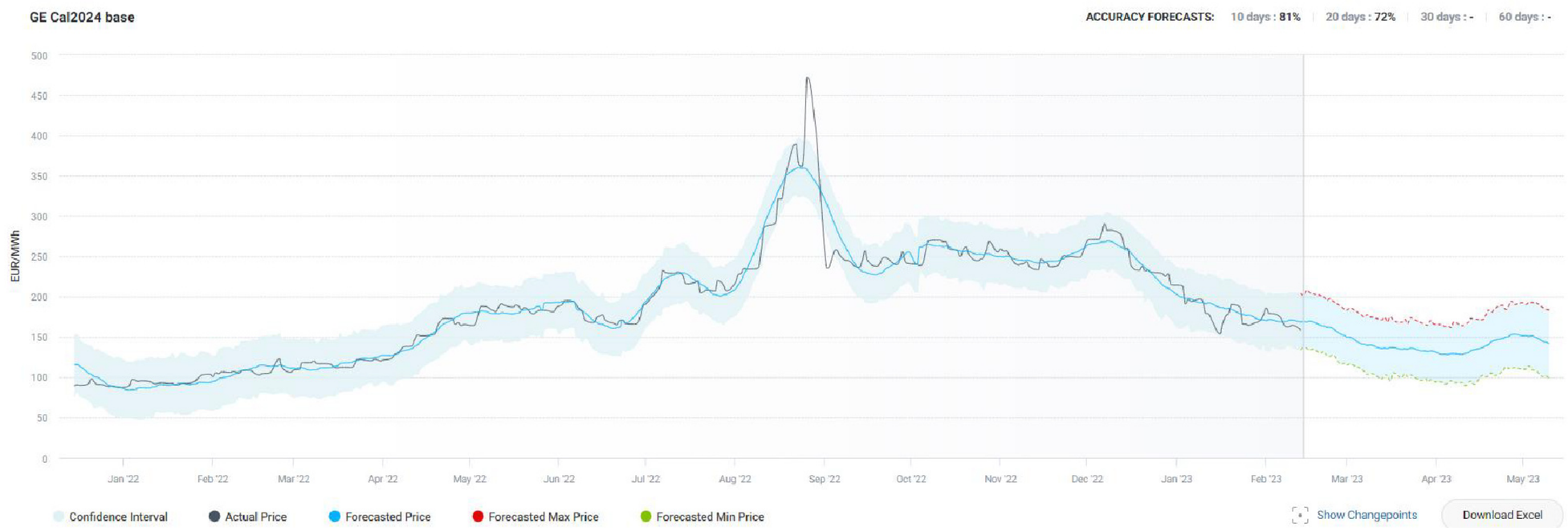
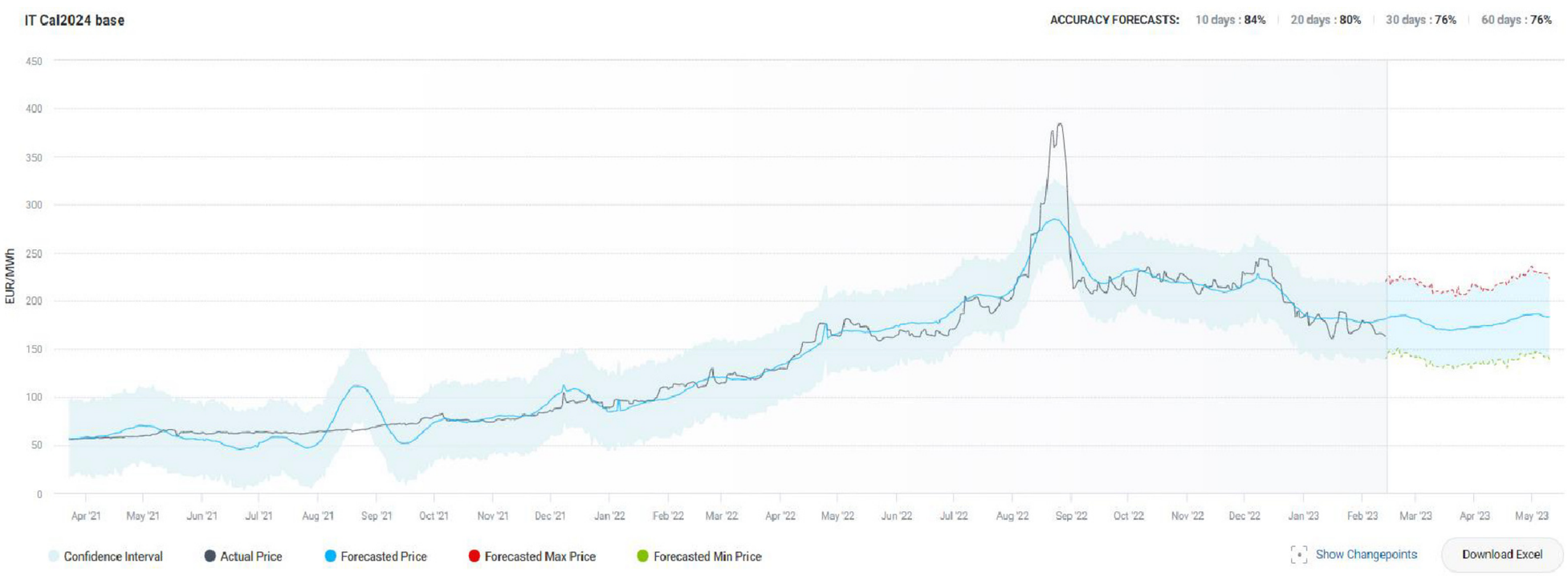
Prophet Results: Vodafone Case

**Power Germany, Italy, France, UK. Forecasts for 3M ahead.**



## How to be used?

- Daily use, however, not mandatory as clients can retrieve results on a weekly or monthly basis. In a volatile environment the model should be used frequently. Timing is key and supported by other factors is when best decisions are made.
- In a stable environment as for example the beginning of 2021, and 2020 or 2019, model is used more rarely, since the trend holds for longer periods.
- With the help of an EMP analyst or solely. Parameters can be tailored according to the needs.

### Annex 1: What is the methodology of Prophet:

Prophet Machine learning Tool uses an advanced statistical methodology (GAM) to calculate detailed price curves, providing base, low and high price forecasts, depending on the confidence interval set. The model learns from past behavior and adjust to non-linear effects. It is trained to obtained most accurate parameters depending on the accuracy methodology.

The basis equation of the model is as follows:

$$y_t = g(t) + s(t) + h(t) + \varepsilon_t,$$

g(t) describes a piecewise-linear trend (or “growth term”), s(t) describes the various seasonal patterns, h(t)h(t) captures the holiday effects, and εt is a white noise error term

Prophet is flexible enough to handle a wide range of forecasting tasks, including time series data with multiple seasonality, non-linear growth, and missing values. It includes a combination of statistical and machine learning models adjusted exclusively to the market characteristics, granularity of data, period of forecasting and other parameters.

### The key parameters used in Prophet:

- **Trend:** Prophet models the underlying trend in the time series using a piecewise linear or logistic regression model. The parameters for the trend model include the changepoint prior scale and the number of changepoints.
- **Seasonality:** Prophet can model seasonal patterns in the data using Fourier series. The parameters for seasonality include the Fourier order and the seasonality prior scale.
- **Holidays:** Prophet can model the impact of holidays and other special events on the time series data. The parameters for holidays include the holiday prior scale and the country or region for which the holidays are relevant. Prophet also allows the inclusion of custom holiday effects
- **Regressors:** Prophet can incorporate additional regressors that may have an impact on the time series data. The parameters for regression include the prior scale for the coefficients of the regressors.
- **Uncertainty:** Prophet provides uncertainty estimates for its forecasts, which can be controlled using the parameter for the width of the uncertainty intervals.

### Adding a regressor.

In general, a regressor (also called an independent variable or predictor variable) can improve the accuracy of a forecast by providing additional information that can help explain or predict the behavior of the dependent variable being forecasted. For example, in a sales forecasting model, incorporating a regressor like advertising spend can help account for the impact of marketing efforts on sales, leading to more accurate predictions.

However, there are also situations where a regressor may not provide any additional value or may even decrease the accuracy of a forecast. This can occur when the regressor is not strongly correlated with the dependent variable or when there is a high degree of multicollinearity between the regressors, which can lead to overfitting and inaccurate predictions.

In addition to the potential benefits and drawbacks mentioned above, it's worth noting that incorporating regressors in a forecasting model also requires careful consideration of the data and the underlying assumptions of the model. For instance, regressors may introduce seasonality or trend changes in the data, which may need to be addressed by the model.

Moreover, the choice of regressor(s) can greatly impact the accuracy of the forecast. With the help of an EMP analyst, regressors that are both relevant and reliable can be selected and different combinations of regressors can be tested to find the optimal set.