Energy prices in Spain

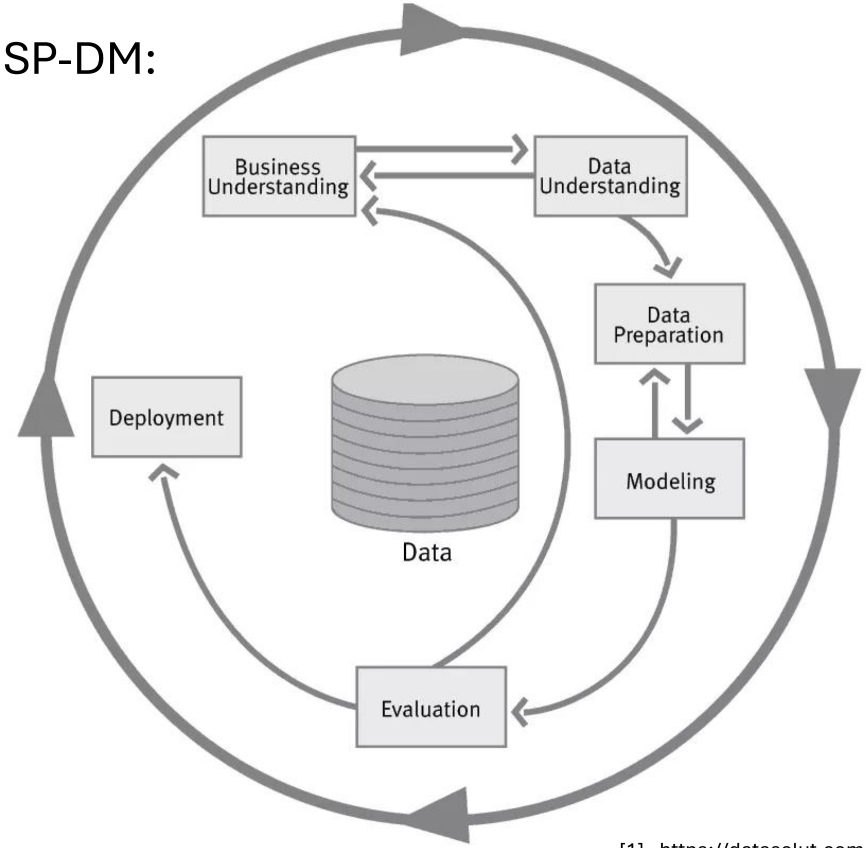
Timeseries forecasting and management summary

1. Workflow – CRISP-DM:

- Forecasts for the Spanish energy transition

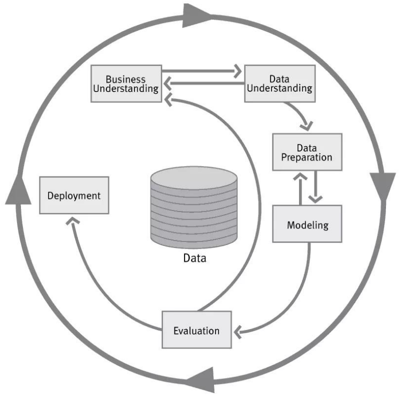
- **Data Preparation and Feature**
    - Checking and removing
    - Checking and removing
    - Check for missing values
    - Fill in missing values with
    - Crete dataset per city fro
    - Restrict dataset to highly
    - Create simple time featu

CRISP-DM:



[1] - https://datasolut.com/crisp-dm-standard/

CRISP-DM:



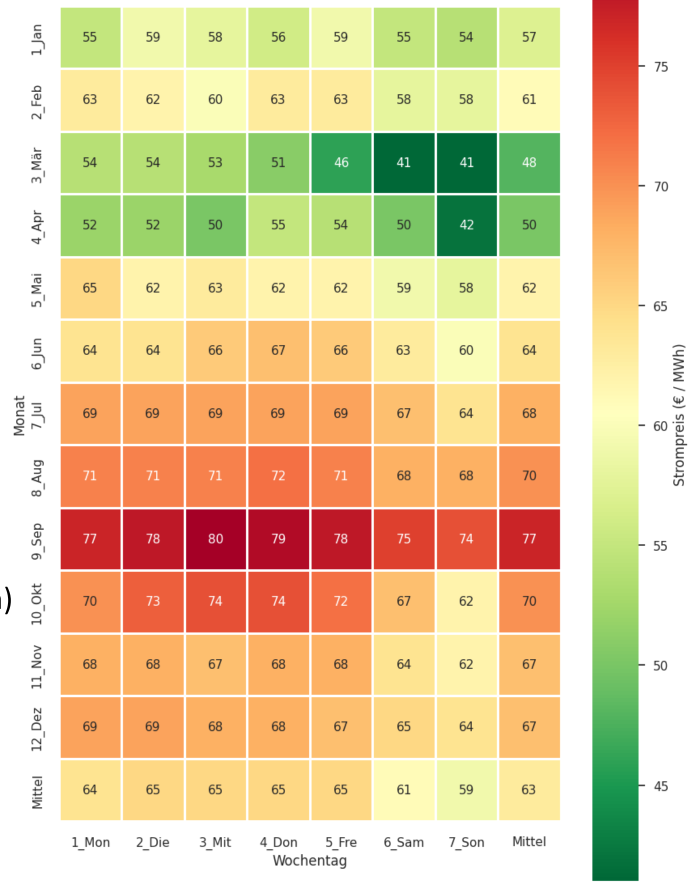
2. Factors influencing the electricity price

- Trends and Seasonality

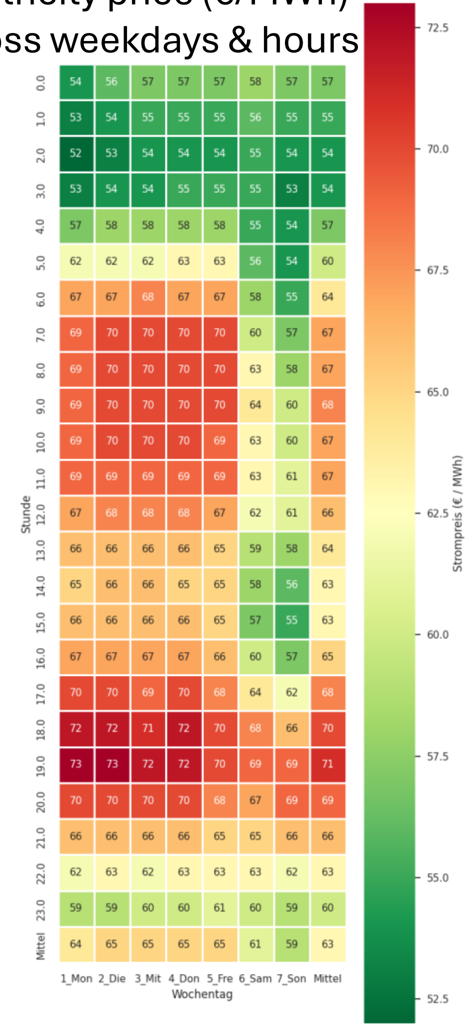
Trends & Seasonality of electricity prices

- **Seasonality**: Montly, daily and hourly
- **Monthly**:
  - Electricity prices tend to be lower in winter
  - Highest electricity prices in late summer (September maximum)
    - Possible reason: high demand (ac) and lower production (water)
  - Does not correlate 1:1 with electricity demand (highest in winter and summer)
- **Daily**:
  - Working days higher than weekends (possible reason: industry)
- **Hourly**:
  - Cheapest at night, most expensive in the evening (5-9 pm)
  - Striking: 13-16 h the electricity price is lower (possibly siesta time in Spain)

Electricity price (€/MWh) across weekdays & months



Electricity price (€/MWh) across weekdays & hours

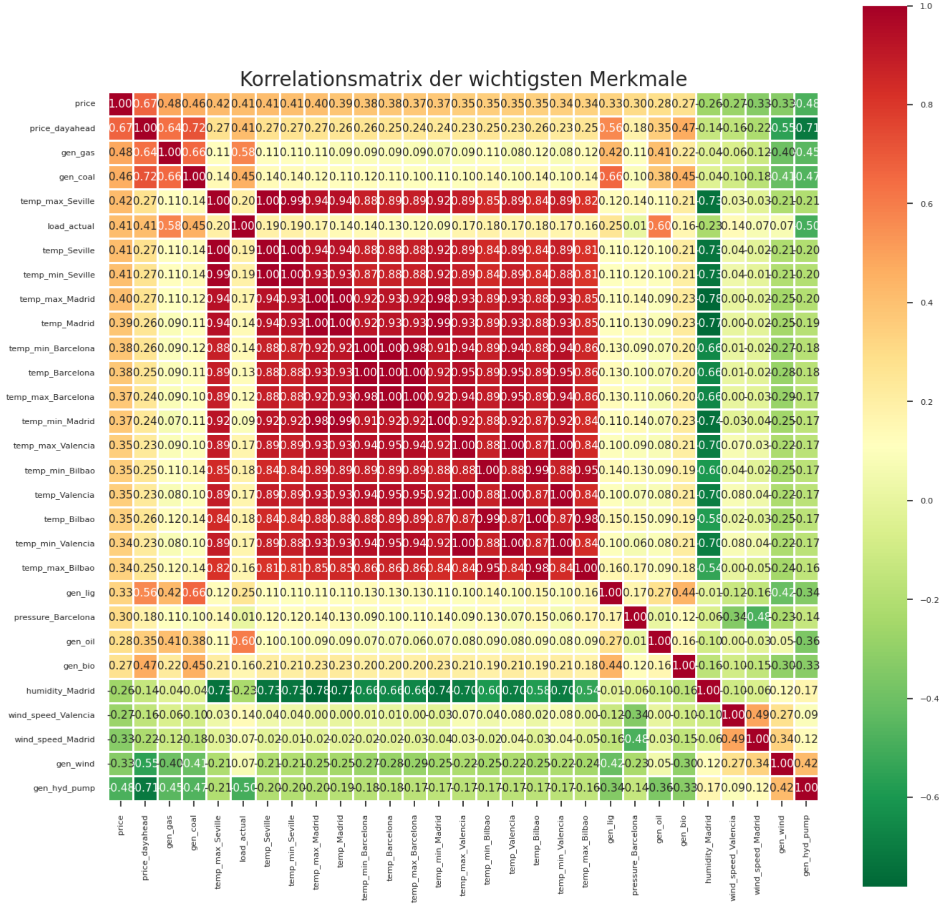


2. Factors influencing the electricity price

- Results of correlationanalysis

Figure: Highest linear correlation to the target variable electricity price

- Positively correlated::
  - Day-Ahead-Preis (0.67)
  - Generation by natural gas (0.48)
  - Erzeugung durch Kohle (0.46)
- Negatively correlated:
  - Generation by hydro pump (-0.48)
  - Generation wind power (-0.33)
  - Wind speed Madrid (-0.33)
- Strong correlation of temperature data between the cities



2. Factors influencing the electricity price

- Results of correlationanalysis

Analysis of the high electricity prices in September compared to the year as a whole revealed

- Higher influencing factor due to consumption (possibly air conditioning systems with high consumption)
- Higher influencing factor Hydropower reservoir (water shortage due to drought → Generation more expensive

Rank	September Merkmal	September Korrelation	Gesamtjahr Merkmal	Gesamtjahr Korrelation
1.	Electricity price	1.0	Electricity price	1.0
2.	Gaserzeugung	0.55	Day-Ahead-Price	0.67
3.	Generation by water reservoir	**0.52**	Generation by gas	0.49
4.	Electricity demand	**0.51**	Generation by coal	0.46
5.	Day-Ahead-Price	0.48	Temp_max_Sevilla	0.42

3. Time series forecast

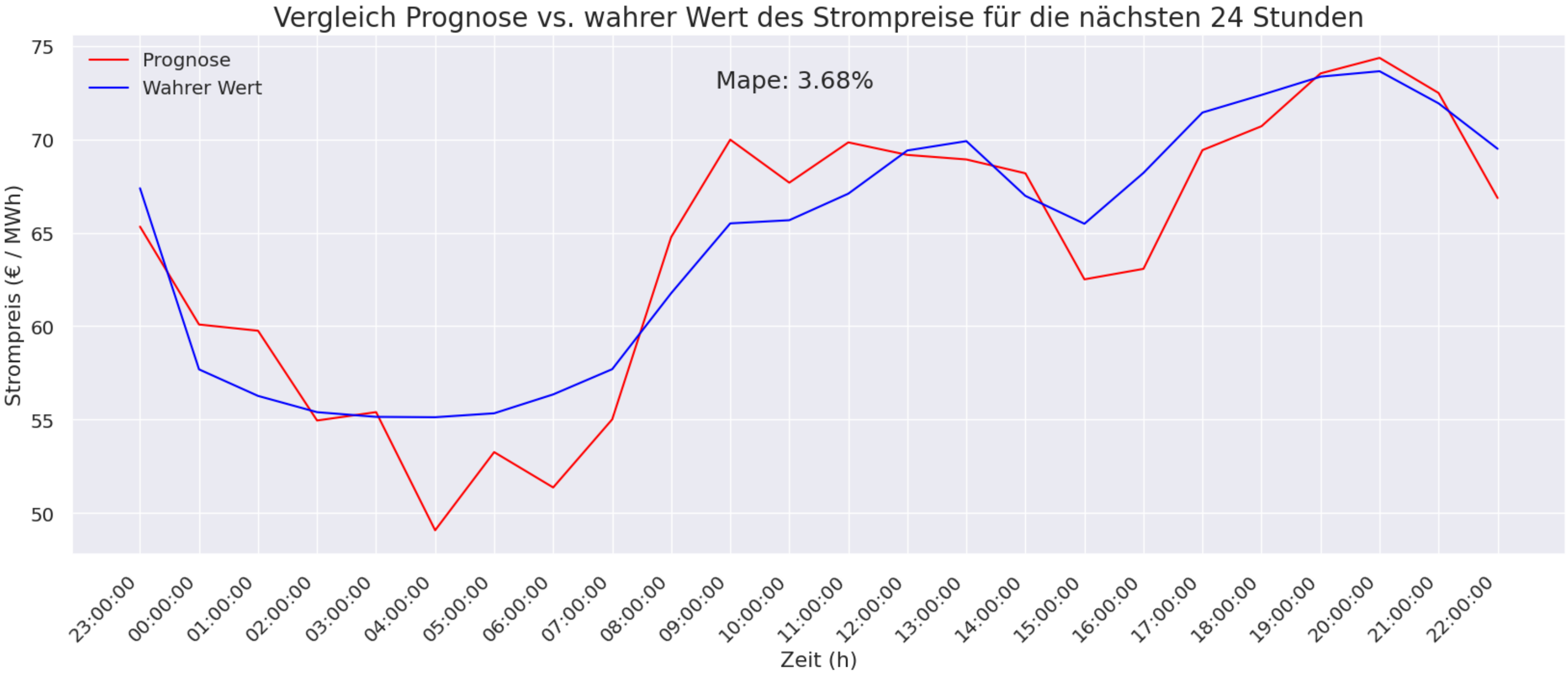
- Comparison of different ML models with cross-validation and AutoML (criteria: **MAPE**)
- Choose EBM (ML-Model) – Explainable Boosting Machine (Regressor)

[2] - https://interpret.ml/docs/ebm.html

Mean absolute percentage error

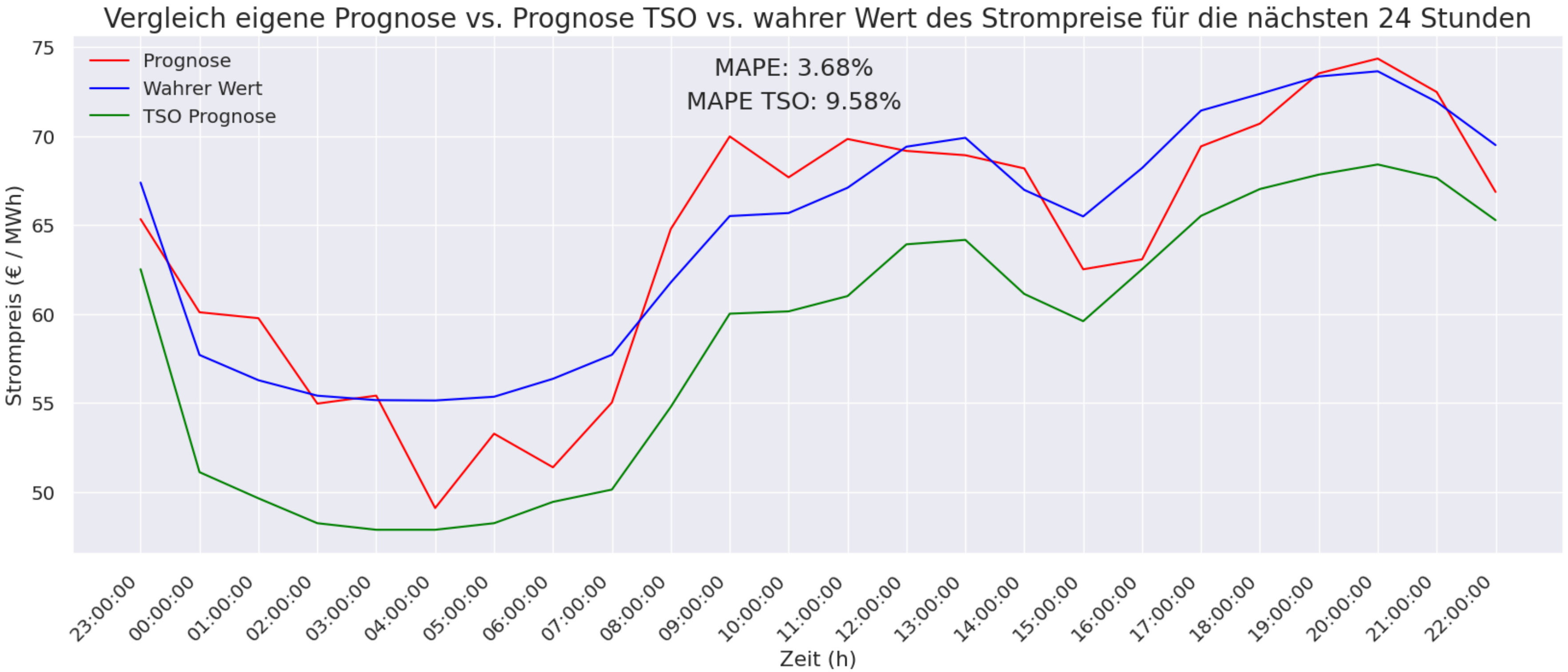
Time	Preis	Preis Prognose	Abs(Preis – Prog.)	Abs / Preis
23:00:00	67	65	2	2 / 67 = 0,029
00:00:00	58	60	2	2 / 58 = 0,035

MAPE = (0,029 + 0,035) /2
= 0,032 → 3,2 %

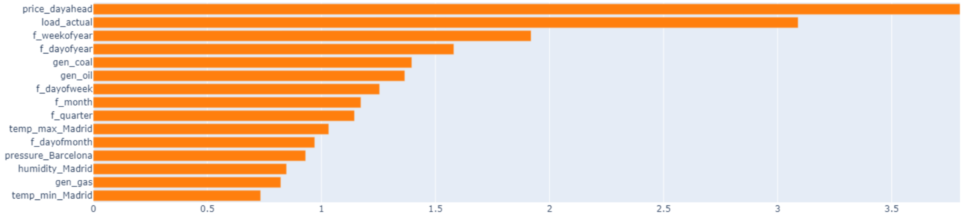


4. Evaluation & Explainability

- Evaluation with TSO:

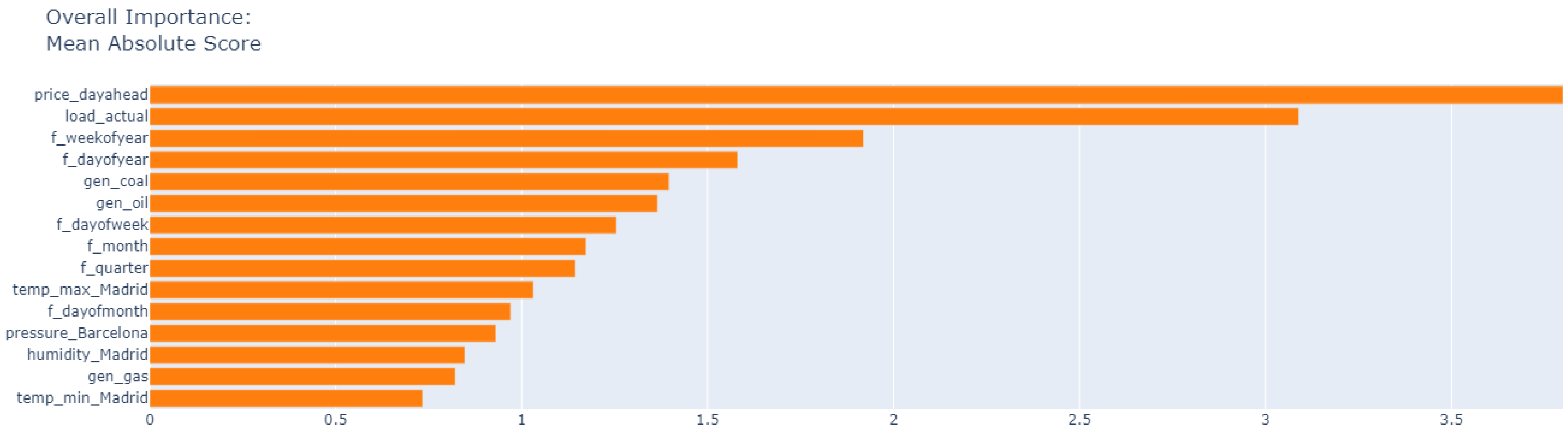


- Interpret Model:
  - **Global:** http://127.0.0.1:7777/140231638982464/
  - **Lokal:** http://127.0.0.1:7777/140231638978864/



4. Global Explainability

- Feature Importance from the EBM model



5. Conclusion and outlook

- **Conclusion**:
  - Influencing factors identified and explained (see chapter 2)
  - Forecast created with very low error (3.5%) for the next 24 hours
  - Recommendation for transmission system operators → Own forecast is significantly more accurate

- **Next steps**:
  - Forecast various weather data and producers for more accurate forecasts and out-of-sample forecasts
  - Detailed analysis of additional features in order to identify further trends and derive new features from them
  - Data set sufficiently large for an approach with artificial neural networks
    - But training computationally and time consuming

6. Additional Slides

Additional slide: Explainable Boosting Machines

- Explainable Boosting Machine (EBM) is a tree-based, cyclic gradient boosting Generalized Additive Model with automatic interaction detection. EBMs are often as accurate as state-of-the-art blackbox models while remaining completely interpretable. Although EBMs are often slower to train than other modern algorithms, EBMs are extremely compact and fast at prediction time.
- Explainable Boosting Machine (interpret.ml)
- Exploring explainable boosting machines

Additional slide: Explain calculation MAPE

Time	Price	Price_Prediction	Abs(price –pred)	(M)APE
23:00:00	67	65	2	2 / 67 = 0,029
00:00:00	58	60	2	2 / 58 = 0,035
				(0,029 + 0,035) /2 **= 0,032 → 3,2 %**