PROSUMER BEHAVIOR MODELING: A PREDICTIVE SOLUTION TO GRID IMBALANCE CHALLENGES

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AGENDA

PROBLEM STATEMENT

INSIGHTS

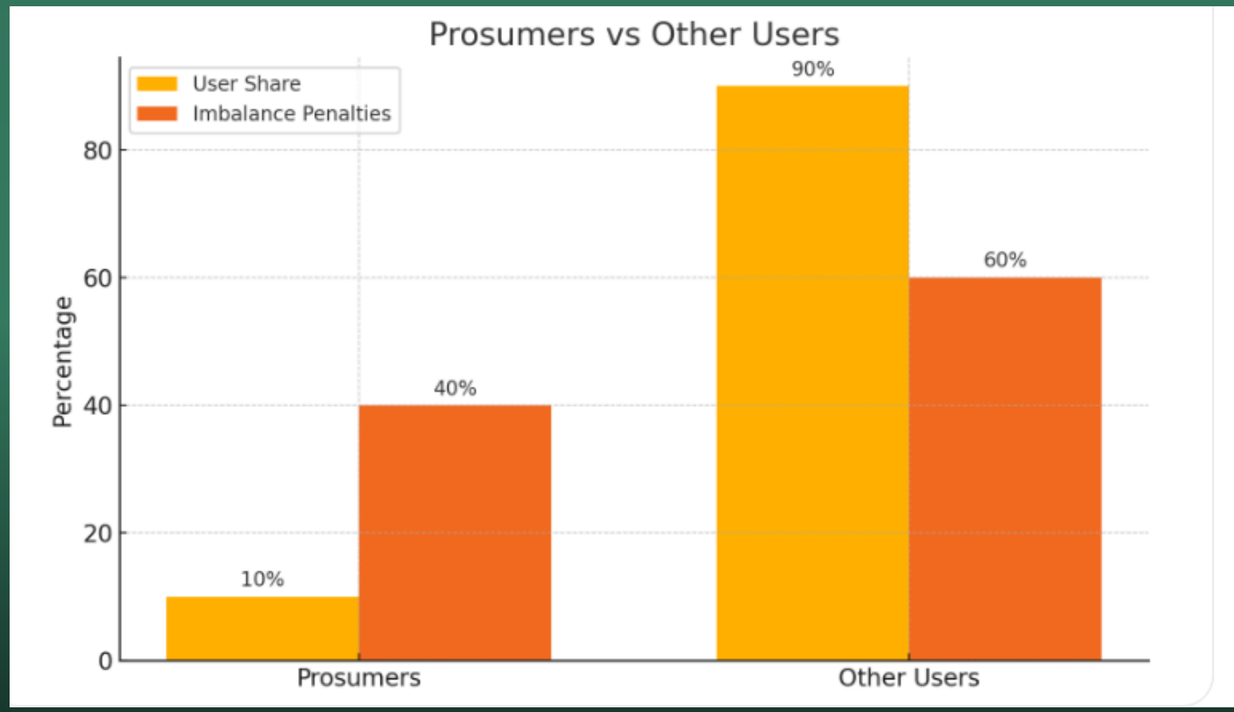
ANALYTICAL FLOW

MODEL SELECTION

CONCLUSION

WHY PROSUMERS MATTER TO ENEFIT

- Prosumers are just 10% of users
- But they cause 40% of imbalance penalties
- Their unpredictable behavior strains grid operations
- Targeting them offers high-impact cost reduction



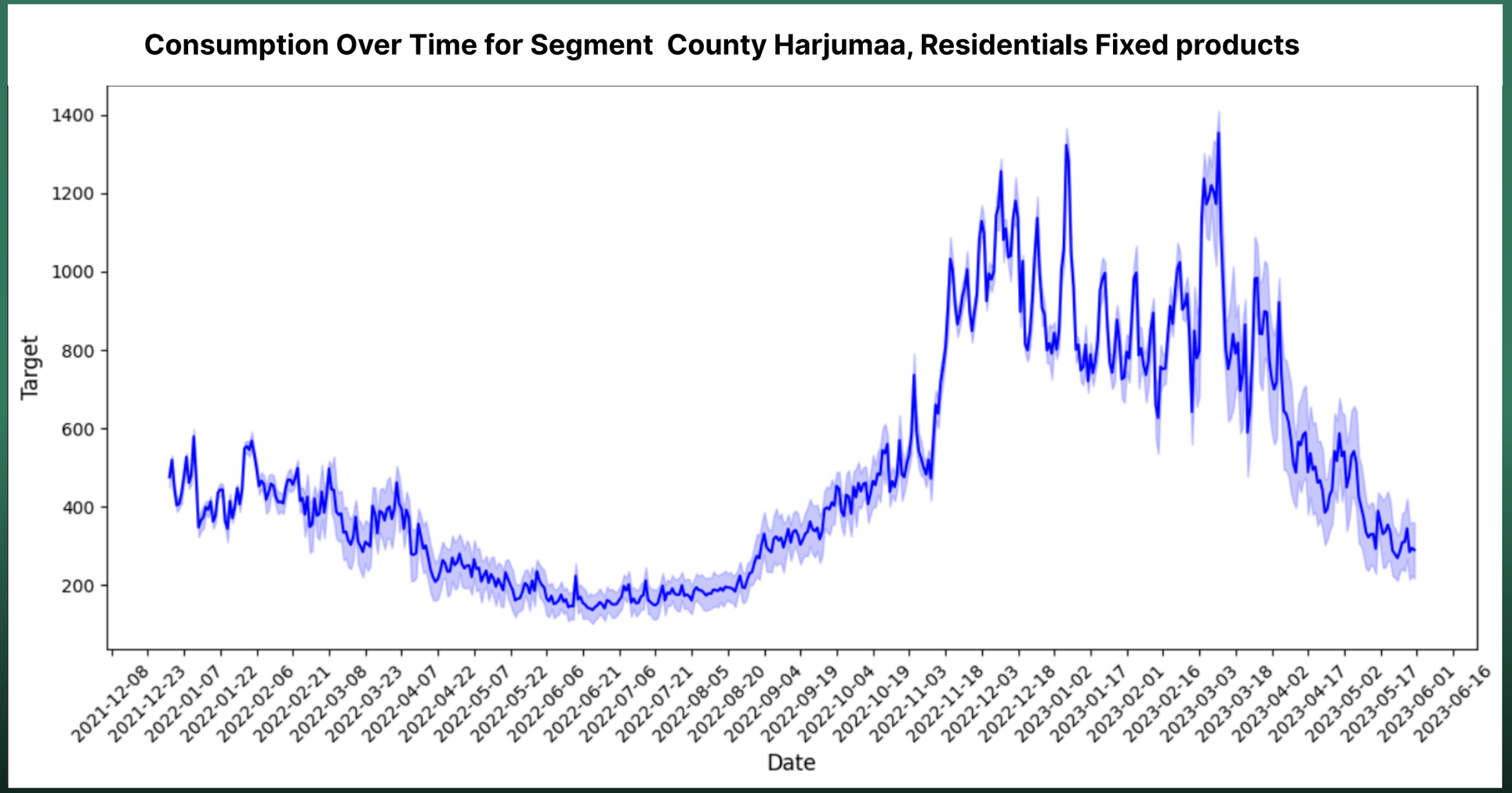
UNDERSTANDING THE CHALLENGE

Situation:
Enefit is facing rising costs and growing grid instability as more customers become prosumers users who both consume and generate electricity, often unpredictably.

Complication:
Existing forecasting models struggle with the complex and volatile behavior of prosumers. As their numbers grow, so do imbalance penalties costing Enefit more and putting strain on grid planning.

Key question:
How can Enefit build a more accurate model to forecast prosumer energy use reducing imbalance costs, improving grid reliability, and enabling a smarter transition to renewables?

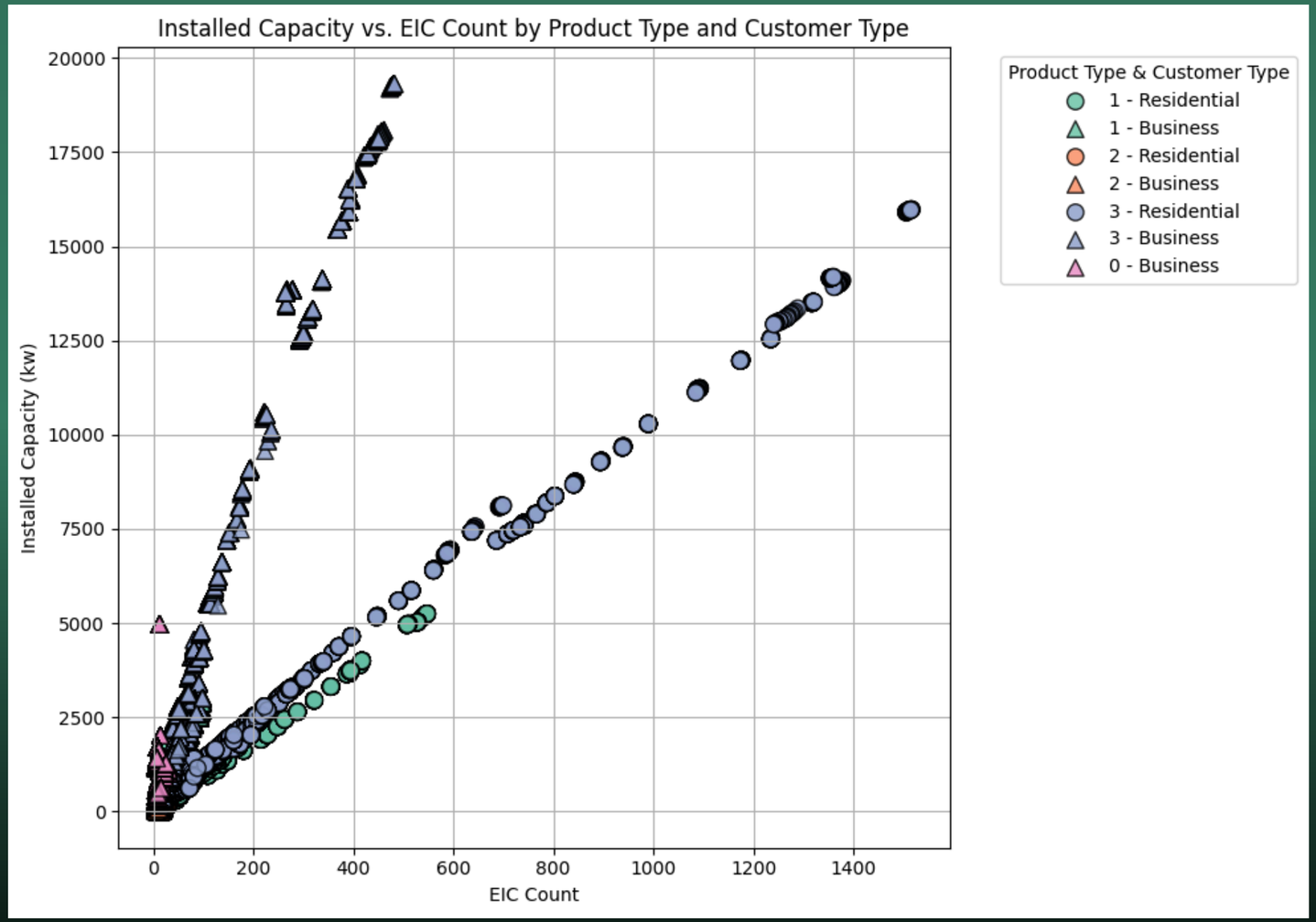
SEASONAL SPIKES HIGHLIGHT THE NEED FOR FORECASTING



We saw clear seasonal trends and sharp usage spikes proving that forecasting prosumer behavior isn’t just helpful, it’s essential.”

INSTALLED CAPACITY VS QTY OF ENERGY IDENTIFICATION CODE(EIC)

- Residential prosumers are more common
- Business prosumers tend to have much higher installed capacities making them key drivers of energy flow and potential imbalance.



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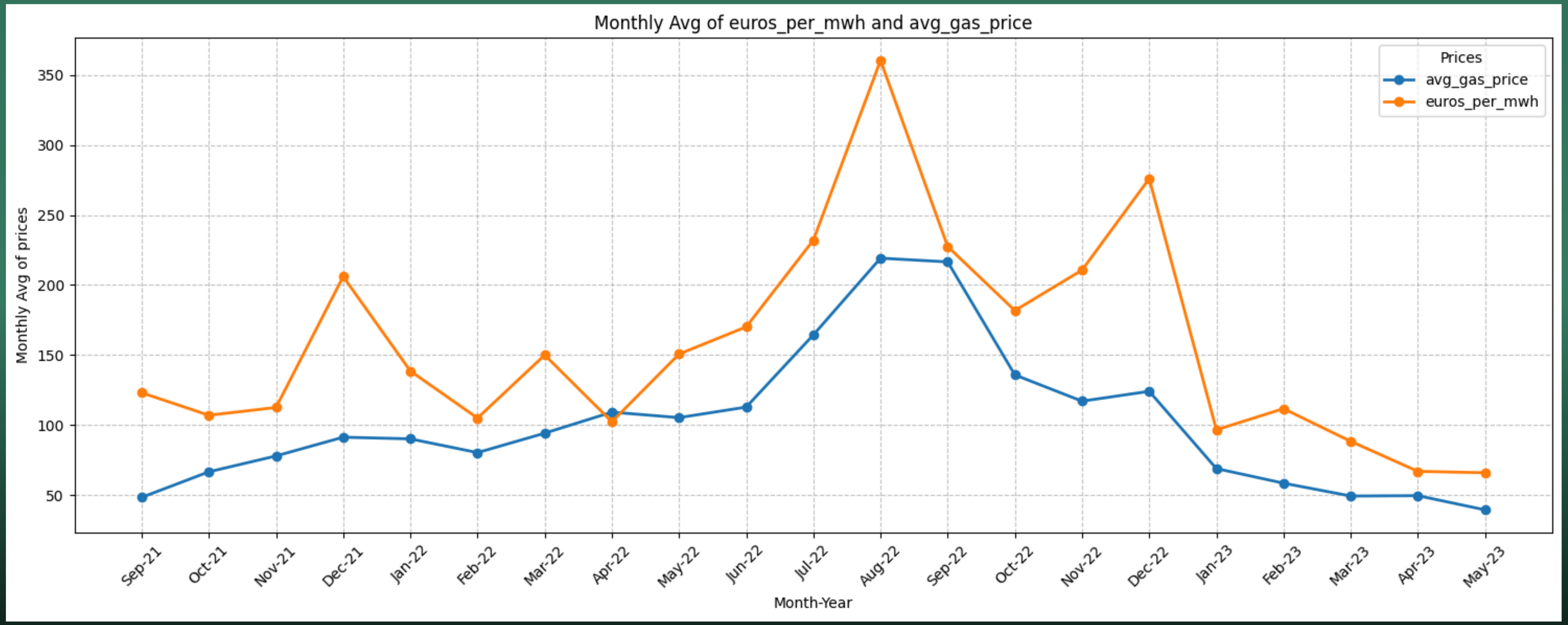
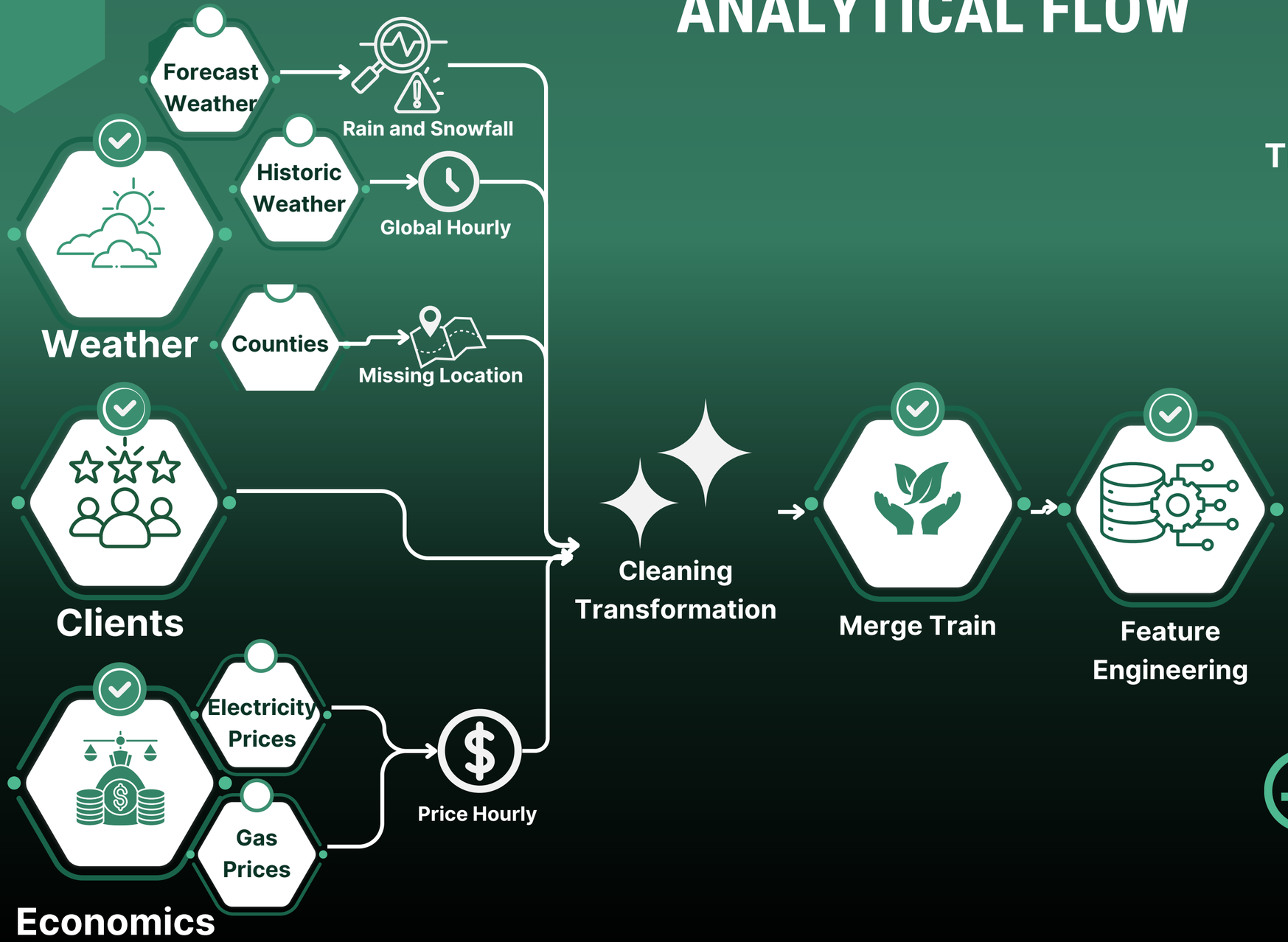


The graph shows monthly averages of electricity and gas prices, peaking in mid-2022, then declining steadily through early 2023, indicating strong price correlation between electricity prices and gas prices.

ANALYTICAL FLOW



Time Based

- month, day, hour
- dayofweek, dayofyear,
- sin/cos of dayofyear

Weather

- solar_rad_x_hour
- temp_x_doy
- wind_speed_est / wind_x_hour
- cloudcover_total_x_solar
- solar_efficiency
- diffuse_radiation_by_county
- irradiance_score
- pv_potential
- wind_chill_proxy

Economic

- price_temp_ratio
- price_signal_strength
- installed_capacity
- euros_per_mwh
- lowest_price_per_mwh,
- highest_price_per_mwh

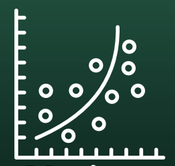
Lag

- target_2_days_ago
- target_3_days_ago
- target_4_days_ago
- target_5_days_ago
- target_6_days_ago
- target_7_days_ago

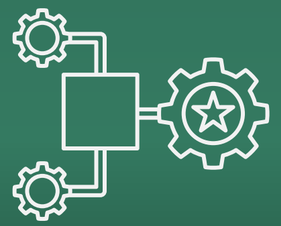
OUR PREDICTIVE MODELING PROCESS

Model Training

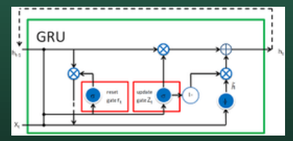
CatBoost



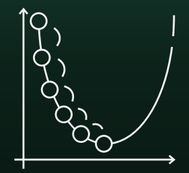
Voting Regressor



Ensemble



GRU



LightGBM

Model Validation

MAE(Mean Absolute Erro) Score

Model Predition

Submission

“We tried a mix of classic and advanced models — each with a different strength.

MODEL SELECTION

We tested 4 models using two key metrics:

- MAE (Mean Absolute Error) → Measures average prediction error
- Kaggle Score → Evaluates real-world performance on unseen future data

Model Name	MAE	Kaggle Score
LightGBM	58	87.5
CatBoost	61	88.06
Ensemble(CatBoost+ LightGBM)	95	133.8
GRU	47	411.7
VotingRegressor(20 LGBM)	41	68.56

VotingRegressor delivered the best balance of score and reliability, making it our top choice

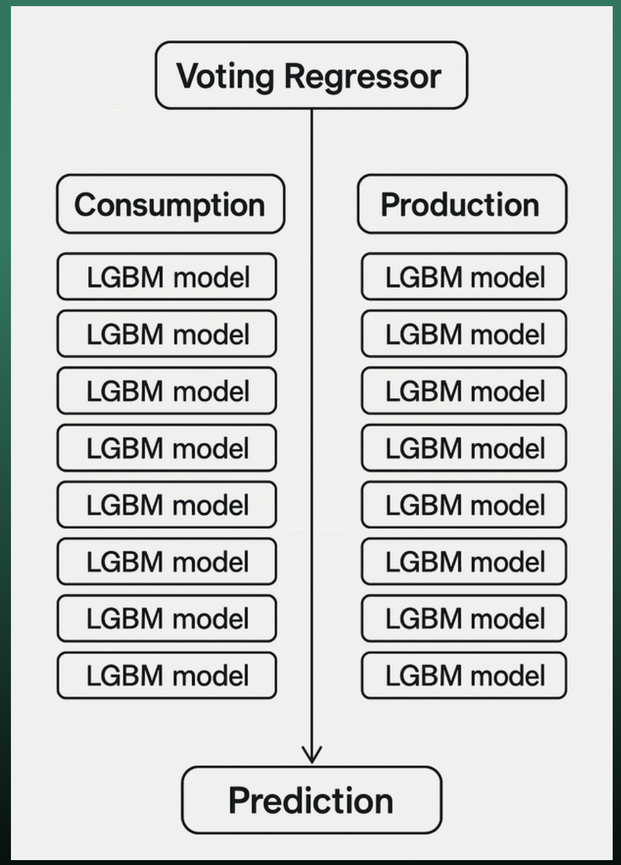
BEST MODEL

After training and testing with 5 models, we come up with our best model for this enefit problem

Voting Regressor with LightGBM

MAE

41



KAGGLE SCORE

68.5

What This Work Enables for Enefit

By accurately forecasting prosumer behavior, Enefit can:

- Cut imbalance penalties through smarter predictions
- Improve operational planning with better visibility
- Support the shift to renewables by managing variability
- Make data-driven decisions instead of reactive ones

This isn’t just about modeling it’s about helping Enefit turn unpredictability into opportunity

CONCLUSION

- Prosumers are a small group creating a big challenge, but also a big opportunity
- VotingRegressor model offers a reliable way to forecast their energy behavior
- Better forecasting means lower imbalance costs, more efficient grid planning, and smarter integration of renewables
- This solution helps Enefit stay ahead of rising operational risks while supporting its green energy vision

THANK YOU!