CAPSTONE PROJECT

IMBALANCE ENERGY

PRICE PREDICITION

neuefische
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01 Introduction

INTRODUCTION :: IMBALANCE

Physical and Technological Constraints

1. Conservation of Energy
2. Grid Instability
3. Low Ability to Store Electrical Energy

→ *The need to match supply and demand every single moment!*

→ *Imbalance is result for false predictions of power supply and demand.*

→ ***How to handle energy imbalances!?***

IMBALANCING ENERGY :: REGULATIVE & QUANTITATIVE

Imbalancing Energy

- Compensate for unforeseen deviation in power demand or power generation
- Allocation is executed by Transmission Operators

Imbalancing Price

- Updated every 15 min
- Calculated by the Transmission Operators
- Published in the following month within 10 business days

→ *Highly delayed price information*

Price Range €/MWh

Year	Min	q.05	Median	q.95	Max
2018	- 1.873	- 37	46	108	2.013
2019	- 2.320	- 39	39	97	2.865
2020	- 6.504	- 61	29	118	15.859

→ *High price range*

Ø Rate of Change

$|\text{Median}|: \frac{36\%}{15\ min}$

$|\text{Mean}|: \frac{275\%}{15\ min}$

→ *Extremly dynamic price development*

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Business Implication

What, if we know the Imbalance Price ahead?

→ *Responding anti-cyclically to the supply situation*

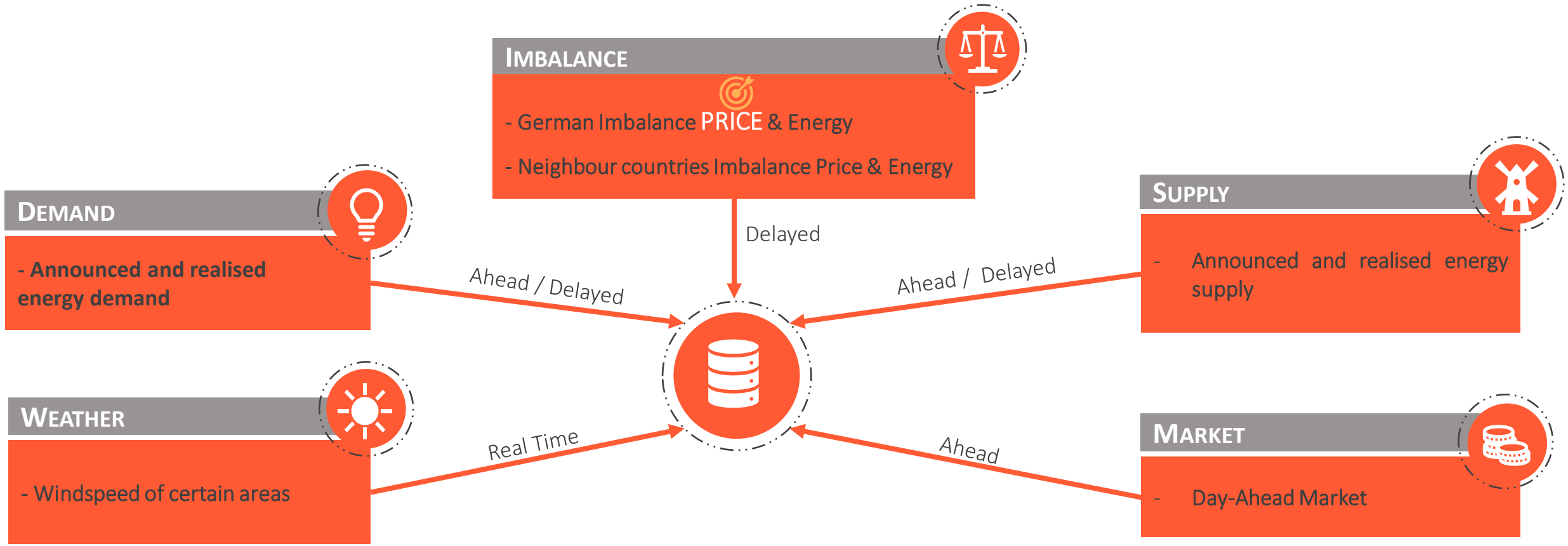
OUR OBJECTIVE :: PRICE PREDICTION

Can we predict the imbalance price several hours ahead?

02

Our Data

OUR DATA SET :: SOURCES AND DESIGN



03

Insights :: Imbalance Price

"*You Are The Average Of The Five People*
You Spend The Most Time With“

Jim Rohn

INSIGHTS :: IMBALANCE PRICE

Time Series Analysis

We didn't detect any significant repeating patterns or cycles in the Imbalance Price. 😢

↪ *The highly delayed Imbalance Price can't be predicted from.*

Data Environment

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Regression

TIME SERIES :: RESULTS

Hours Ahead	Best Model	RMSE €/MWh
1	Encoder-Decoder	59,27
3	Bi-Directional LSTM	71,68
6	GRU	68,23
12	GRU	76,38
24	GRU	79,14

DESIGNED MODELS

- GRU
- CNN
- LSMT
- Bi-Directional LSTM
- Encoder-Decoder

GRU: Gated Recurrent Unit

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Reference

Year	q.05 €/MWh	Median - $RMSE_{1h}$ €/MWh ≈	Median €/MWh	$RMSE_{1h}$ + Median €/MWh ≈	q.95 €/MWh
2018	**- 37**	-14	**46**	106	**108**
2019	**- 39**	-20	**39**	99	**97**
2020	**- 61**	-30	**29**	99	**118**

GRU: Gated Recurrent Unit

Designed Models

- GRU
- CNN
- LSMT
- Bi-Directional LSTM
- Encoder-Decoder

Observation

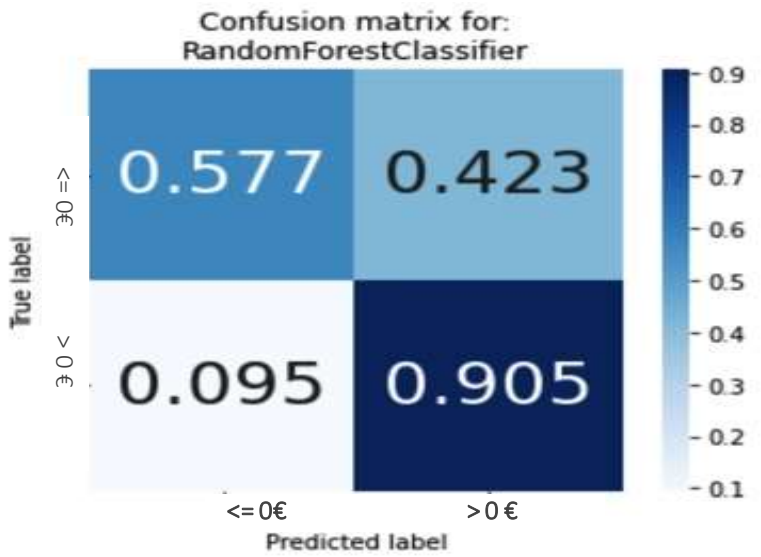
The RMSE is slightly less, than the difference between median an the 90% boundaries of the last three years

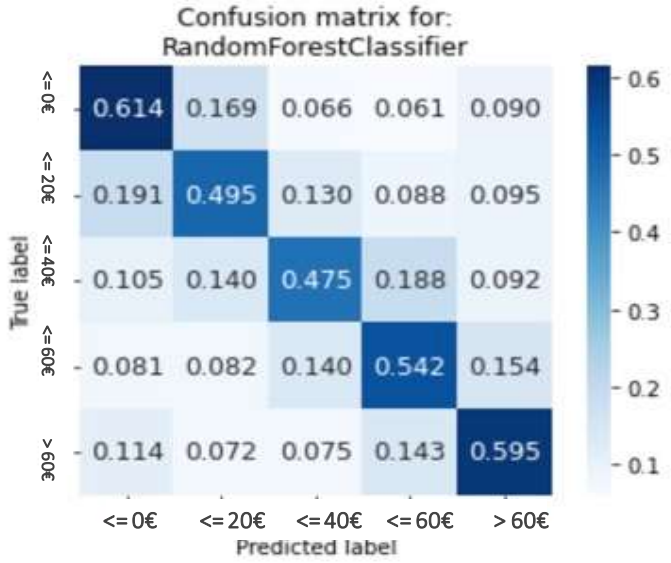
Conclusion:
Low precision at present stage.

05

Classification

TIME INDEPENDENT APPROACH





What is the ***overall*** performance of our best model?

Classification Setup	Accuracy
Positive and Negative Prices	83.5 %
5 Price Segements	54%

Designed Models

- PCA + Random Forest Classifier
- Random Forest
- PCA + Gaussian Naive Bayes

Designed Classes

- Positive and Negativ Prices
- <0 | ≤20 | ≤ 40 | ≤60 | ≥60

Observations

Random Forest is capable of predicting booth the lowest and highest rebap prices with close to 60% accuracy.

Conclusion: The model works very well for the classes *positive and negative prices* and acceptable for *5-Bucket classification.*

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Summary

SUMMARY

1 Insights

Imbalance Price Characteristics

- Delayed publication,
- High price range and volality,
- Price can‘t be predicted from its history.
- Low correlation with given data

2 Predictions

Regression Approach

- Low precision at present stage.

Classification Approach

- Classification of **positive and negative prices** with a total **accuracy** of **83.5 %.**
- Price classification with **5 price segments** leads to an **accuracy of 54%.**

07

OUTLOOK

OUTLOOK :: WHAT COULD LEAD TO BETTER RESULTS?

Additional Data Mining

- Expand with additional Weather Data

Feature Engineering

- Methods Technical Analysis of the Financial Markets

Modeling

- Error Analysis