Prediction of Renewable Power Loss caused by Feed-In Management

Using Advanced Linear Models and Recurrent Neural Networks for Time Series Predictions

26.November 2020

Tjade Appel

- B.Eng. in Mechanical Engineering
- M.Sc. in Sustainable Energy Systems
- M. Thesis: Modelling Environmental Conditions for the Design of Offshore Wind Turbines
- 1 year internship experience in the energy industry
- If you want to talk sports, I'm your man!

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Let’s explore together! Data, Systems, Cultures, Models.

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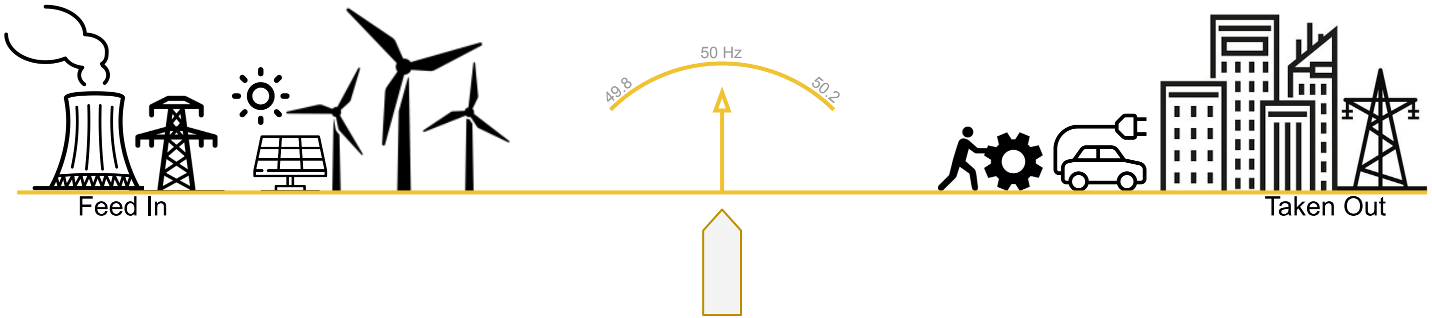
Energy fed into the system needs to equal energy taken out of the system at all times. This was already difficult with conventional electricity generation. It is even more difficult with a combination of volatile renewable energy sources. For example, on a windy and sunny day in June, there is potentially a lot of excess wind energy. Feed-In Management describes the curtailment of energy to protect grid infrastructure of overloads.

What if we could instead use the excess energy?



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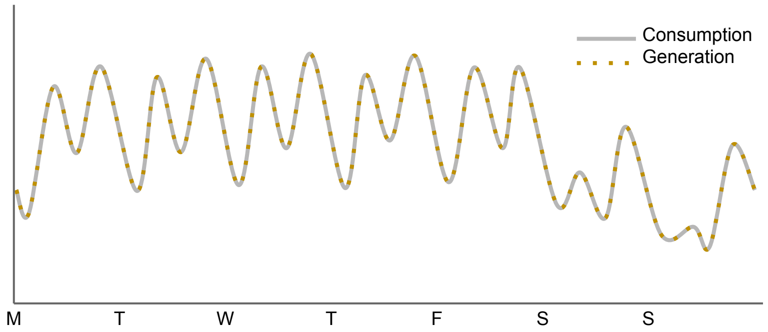
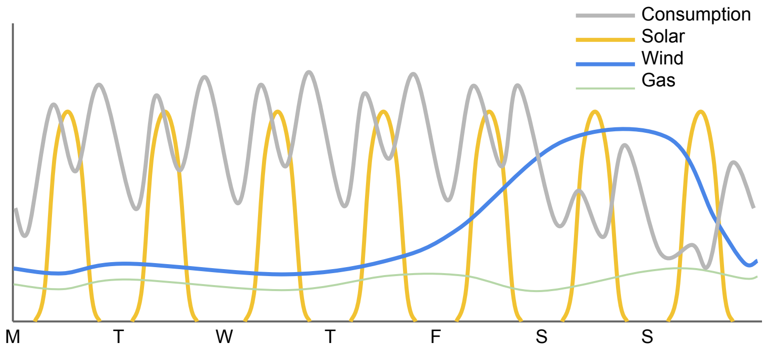
Conventional Electricity Grid



Renewable Electricity Grid



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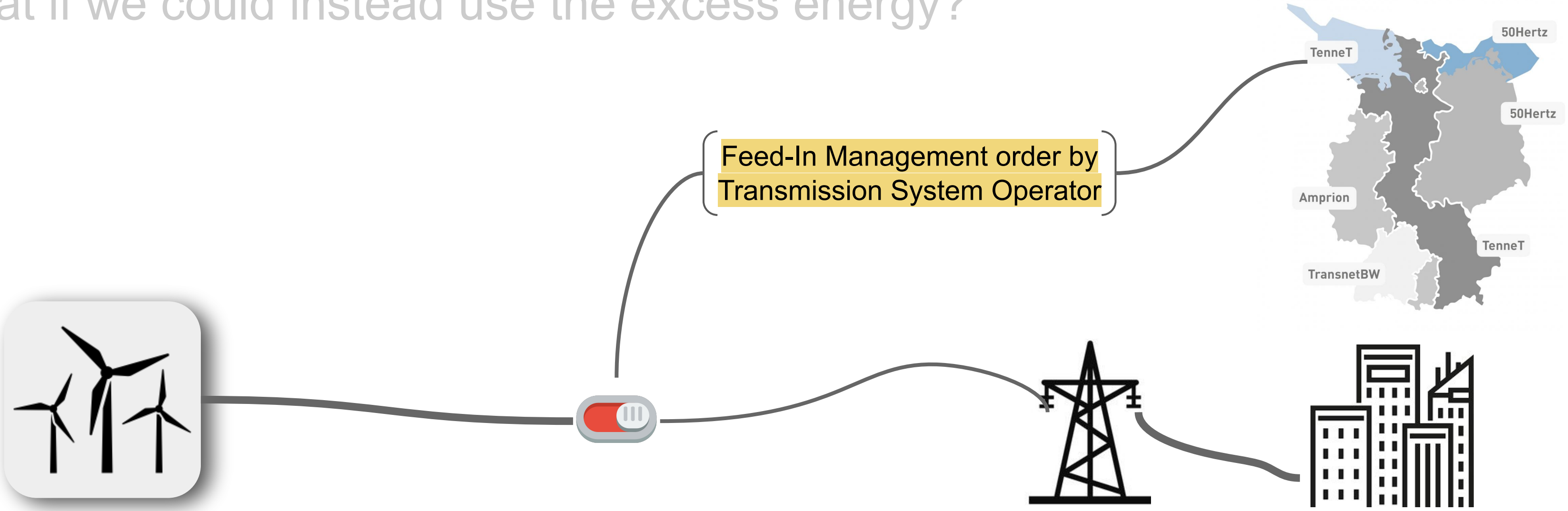

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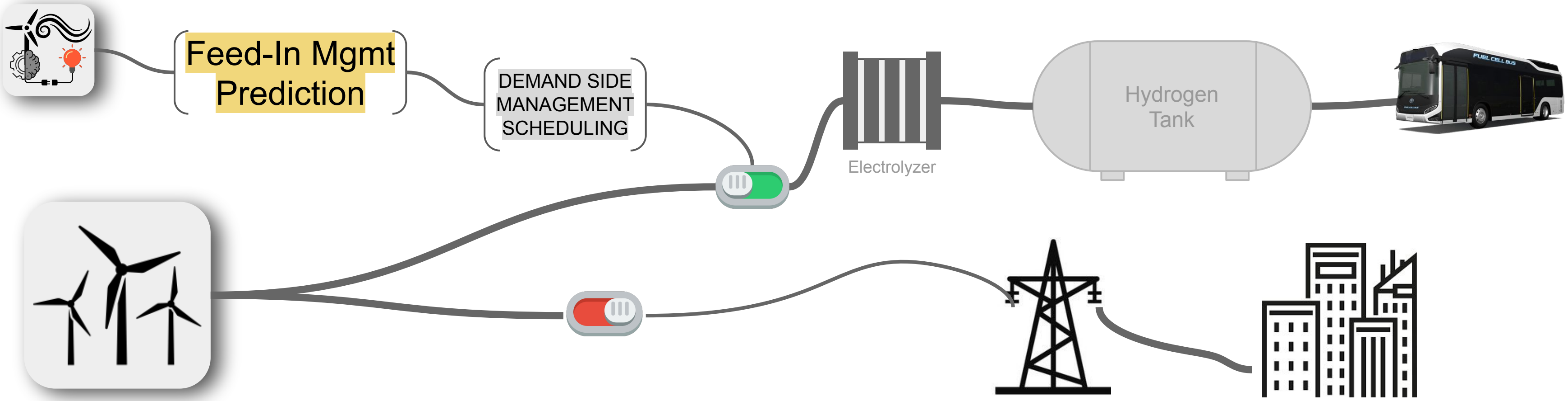

BACKGROUND

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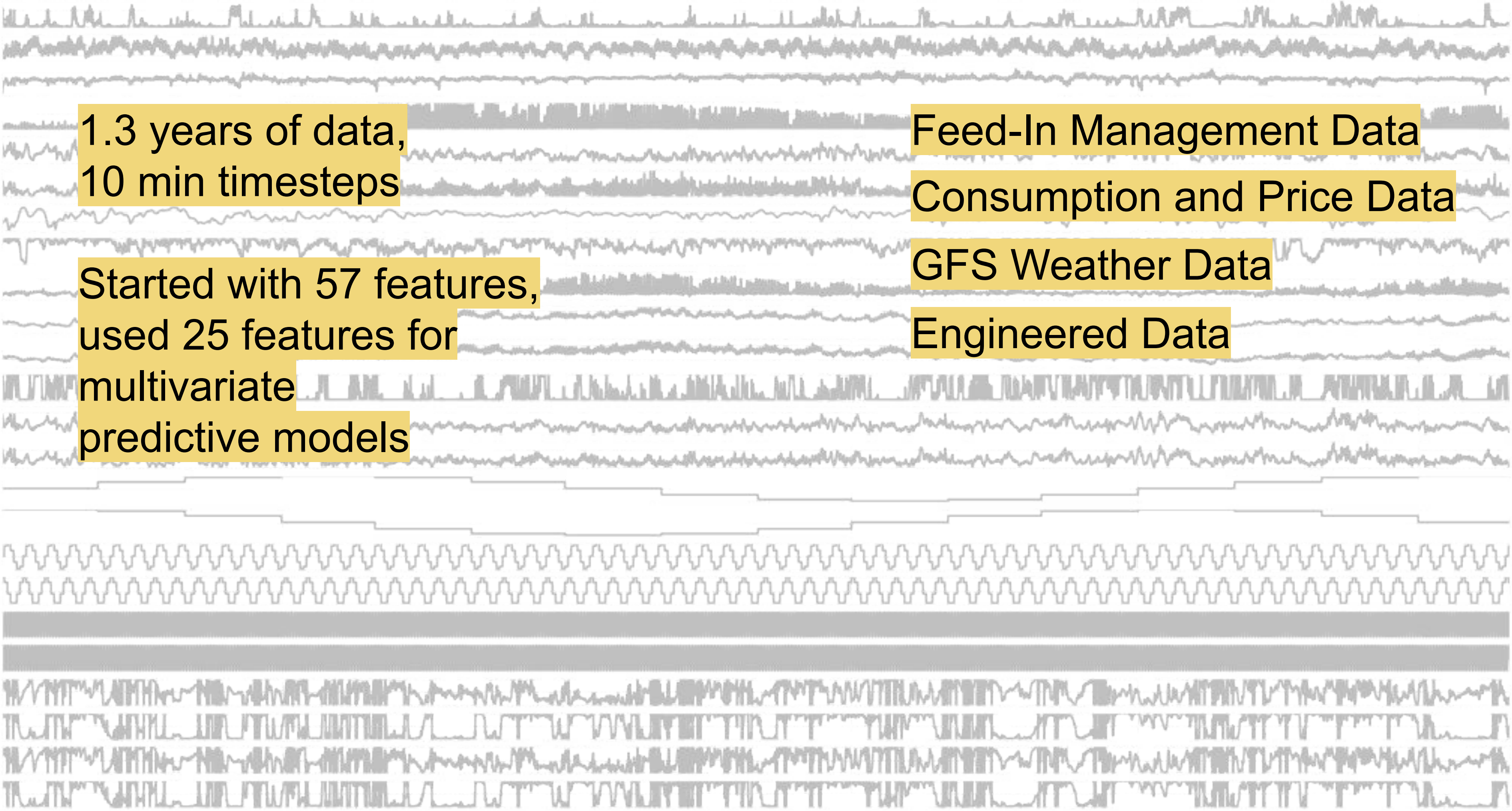
FUTURE WORK

Onshore Wind Farm in Twistringen, Germany. 6 Enercon E66 and 6 E70 turbines with 22,8 MW installed capacity



1.3 years of data,
10 min timesteps

Started with 57 features, used 25 features for multivariate predictive models

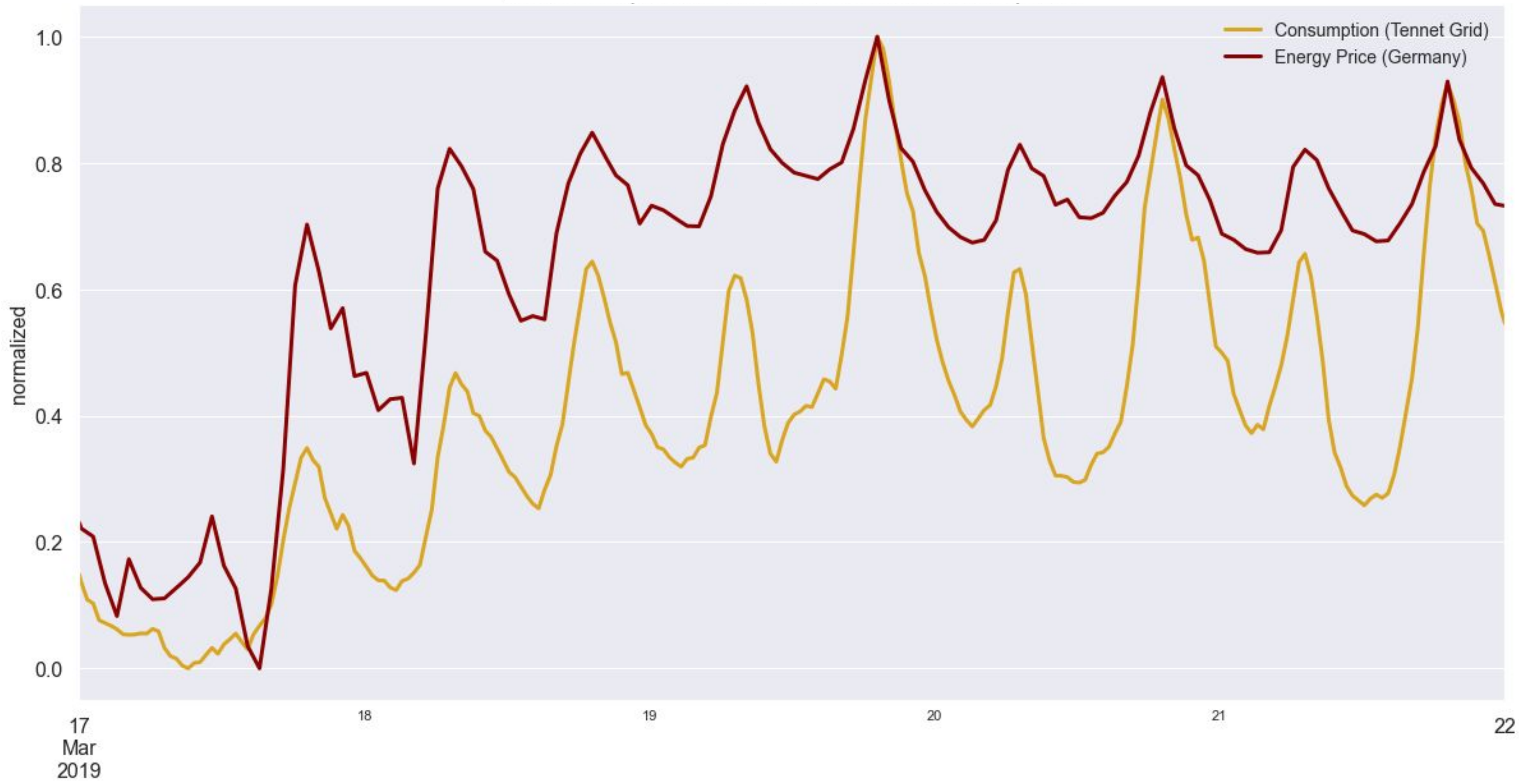
Feed-In Management Data

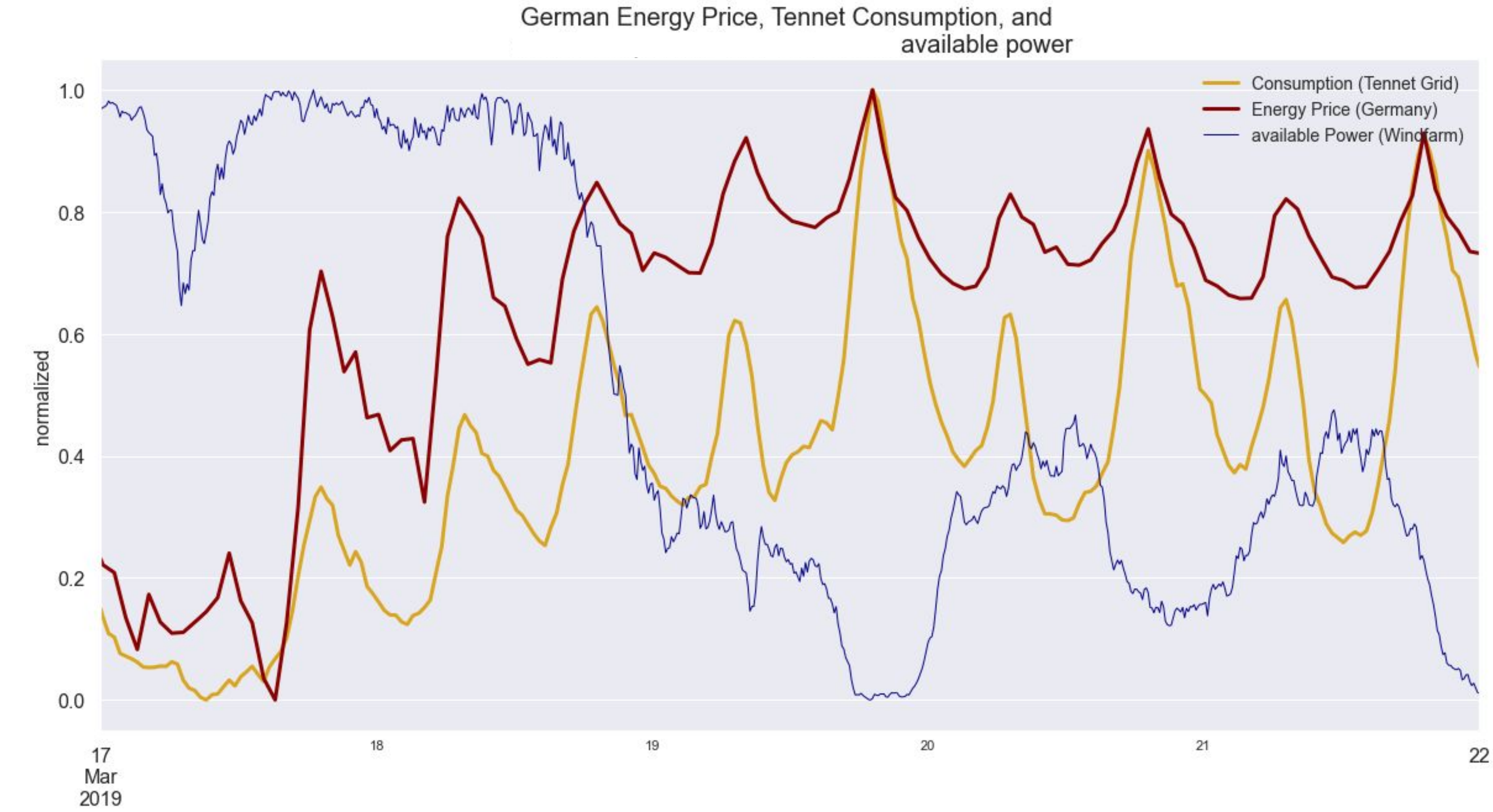
Consumption and Price Data

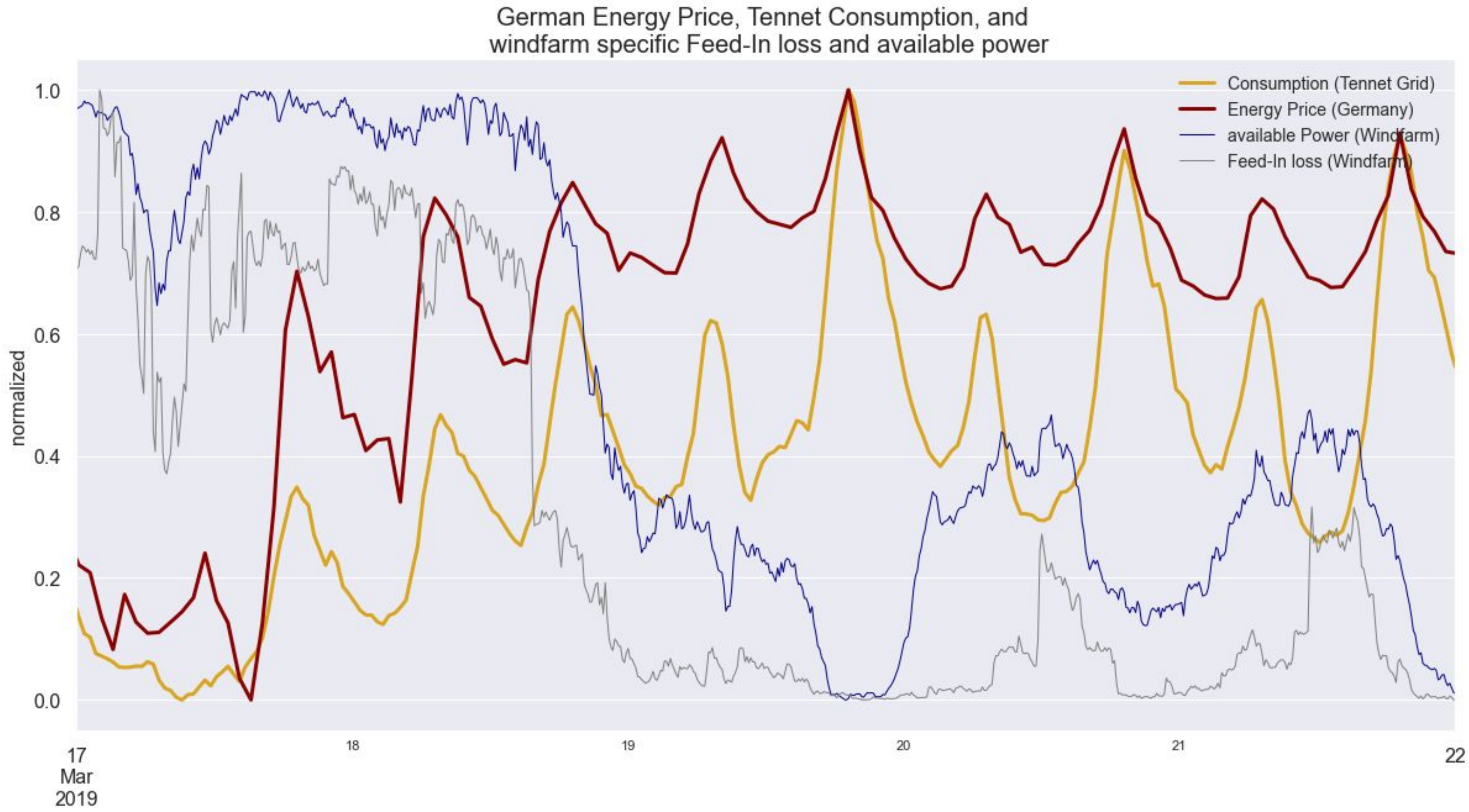
GFS Weather Data

Engineered Data

German Energy Price, Tennet Consumption




German Energy Price, Tennet Consumption, and available power
Consumption (Tennet Grid)
Energy Price (Germany)
available Power (Windfarm)
normalized
1.0
0.8
0.6
0.4
0.2
0.0
17
Mar
2019
18
19
20
21
22


German Energy Price, Tennet Consumption, and
windfarm specific Feed-In loss and available power
Consumption (Tennet Grid)
Energy Price (Germany)
available Power (Windfarm)
Feed-In loss (Windfarm)
normalized
1.0
0.8
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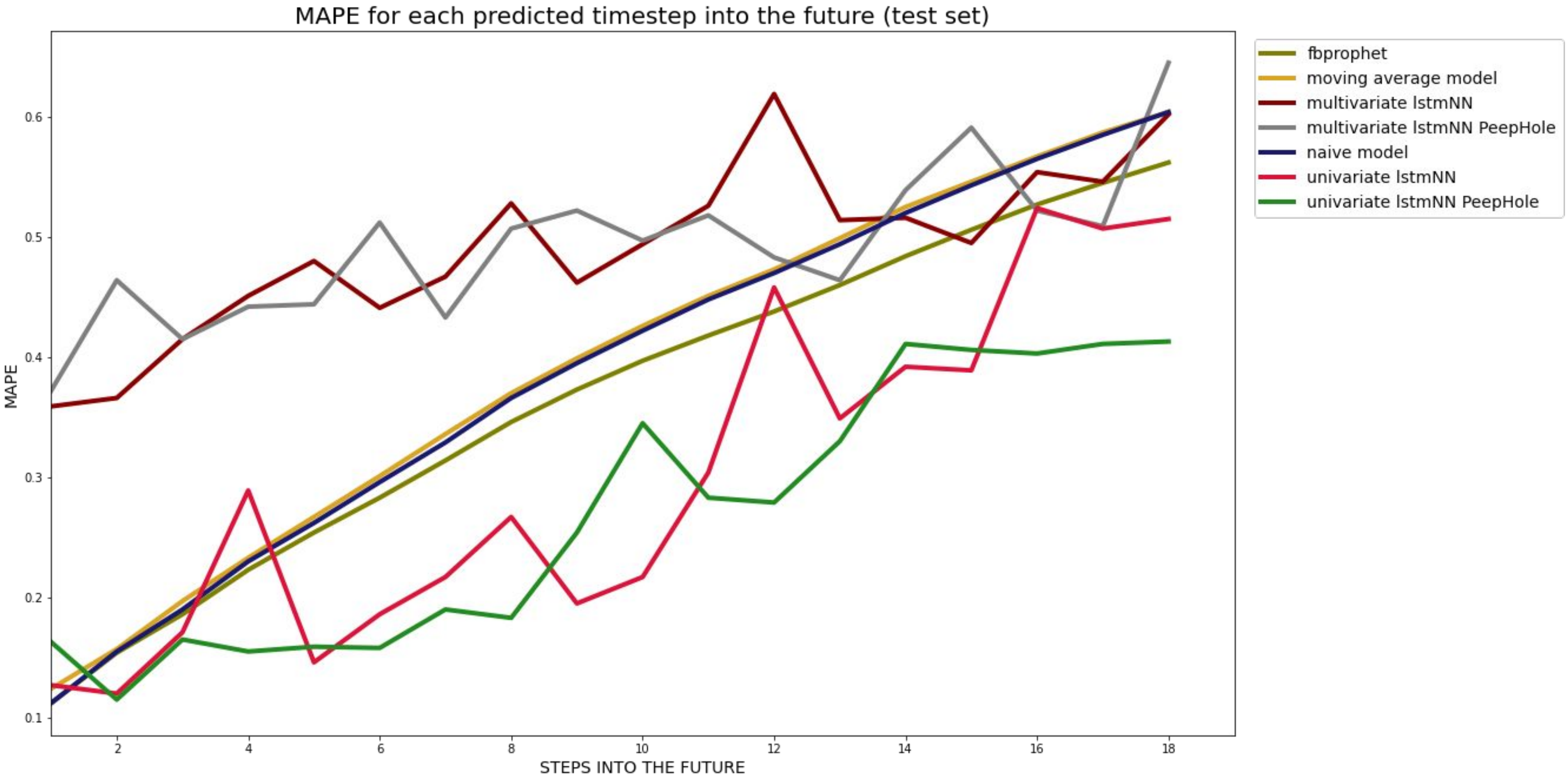
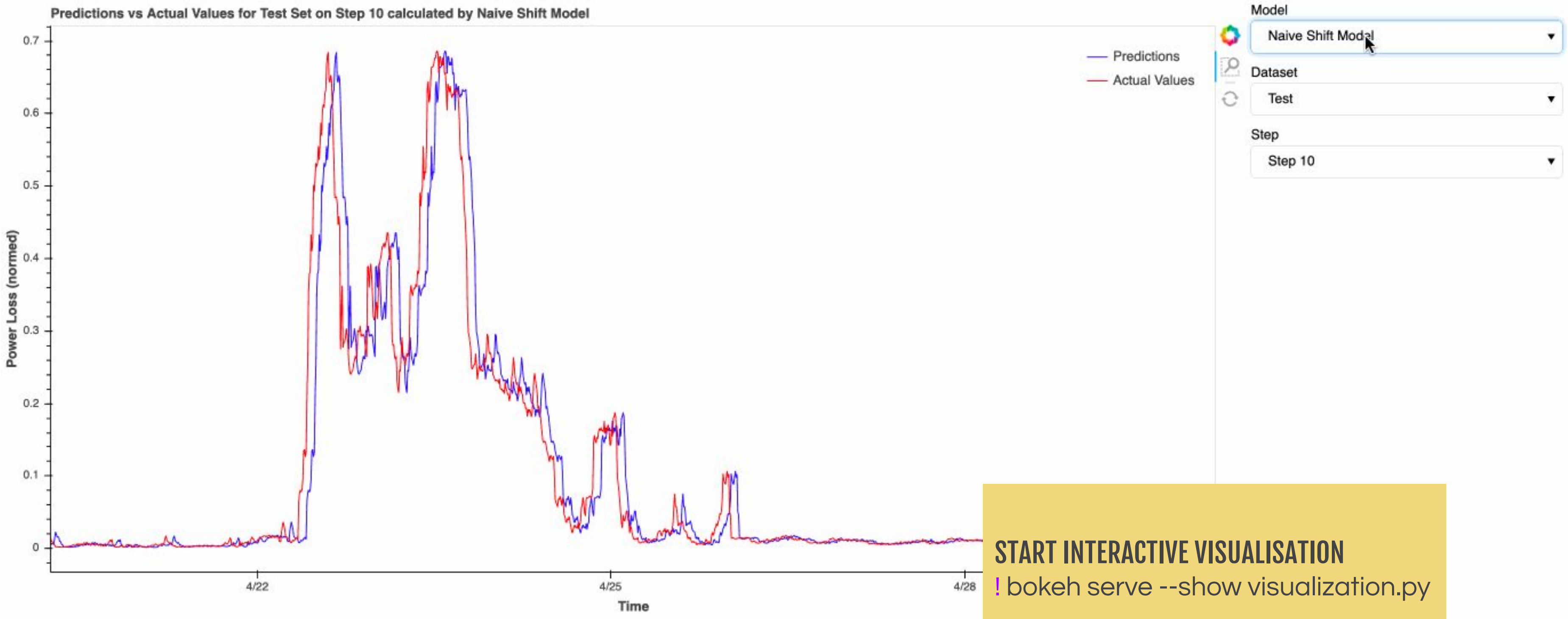
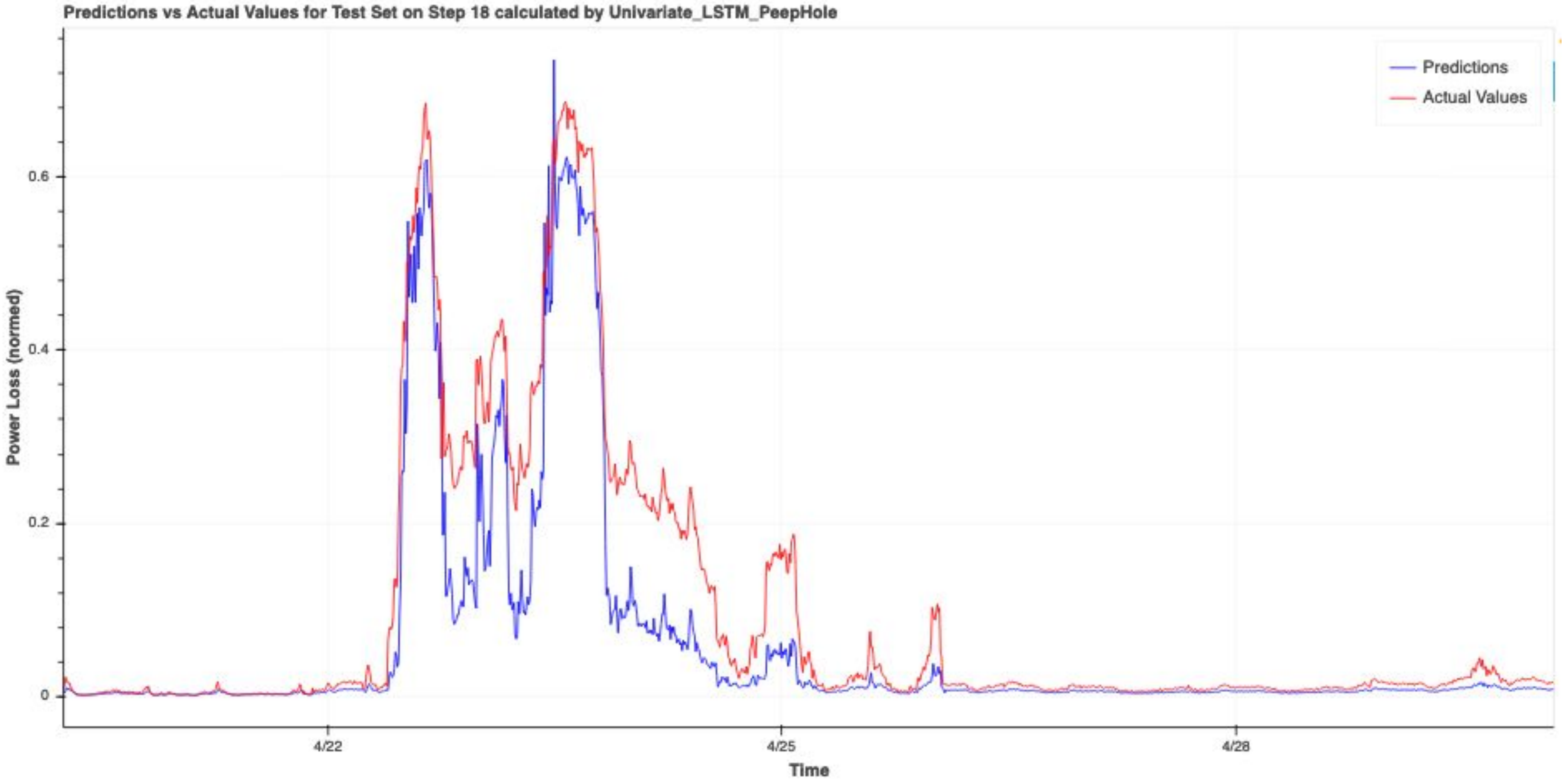

MAPE for each predicted timestep into the future (test set)
MAPE
STEPS INTO THE FUTURE
0.1
0.2
0.3
0.4
0.5
0.6
2
4
6
8
10
12
14
16
18
fbprophet
moving average model
multivariate lstmNN
multivariate lstmNN PeepHole
naive model
univariate lstmNN
univariate lstmNN PeepHole



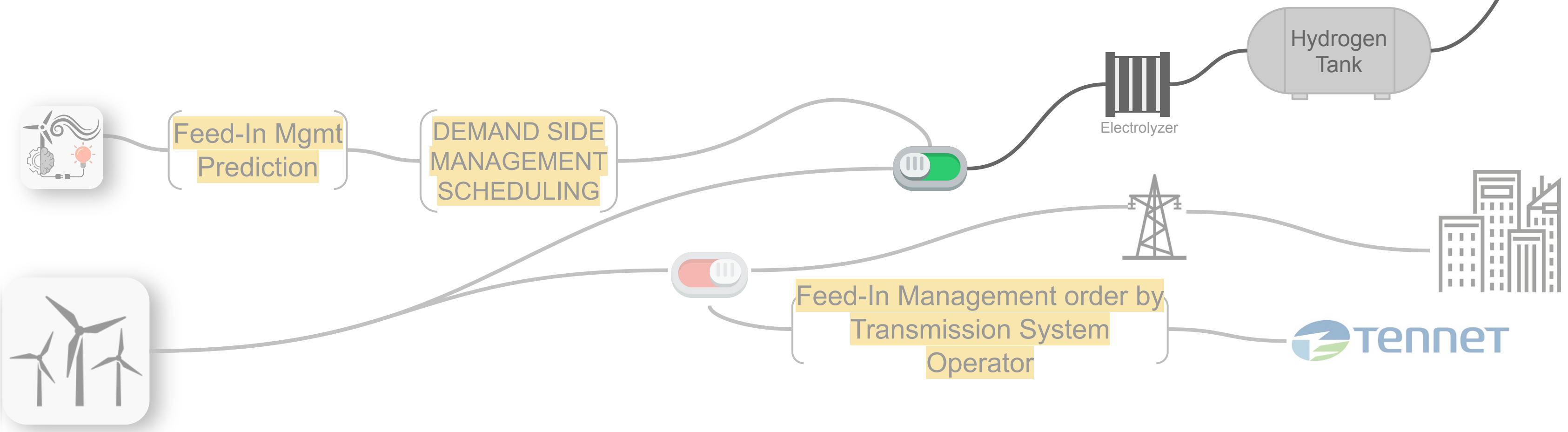
START INTERACTIVE VISUALISATION

! bokeh serve --show visualization.py


Predictions vs Actual Values for Test Set on Step 18 calculated by Univariate_LSTM_PeepHole
Predictions
Actual Values
Power Loss (normed)
0.6
0.4
0.2
0
4/22
4/25
4/28
Time

Simplifications:
- energy to hydrogen conversion rate: 48 kWh/kg
- fuel cell passenger bus 13.3 kg H_2/ 100 km
- no ramp-up time, no extra logistics

	Lost Power in MWh	Lost Power (forecasted) in MWh	Percentage in %	Potential Mileage of Fuel Cell Bus in km
Prediction 10 minutes ahead	503	495.0	98.4	77343
Prediction 1.5 hours ahead	503	451.9	89.8	70609
Prediction 3 hours ahead	**503**	**322.3**	**64.1**	**50359**



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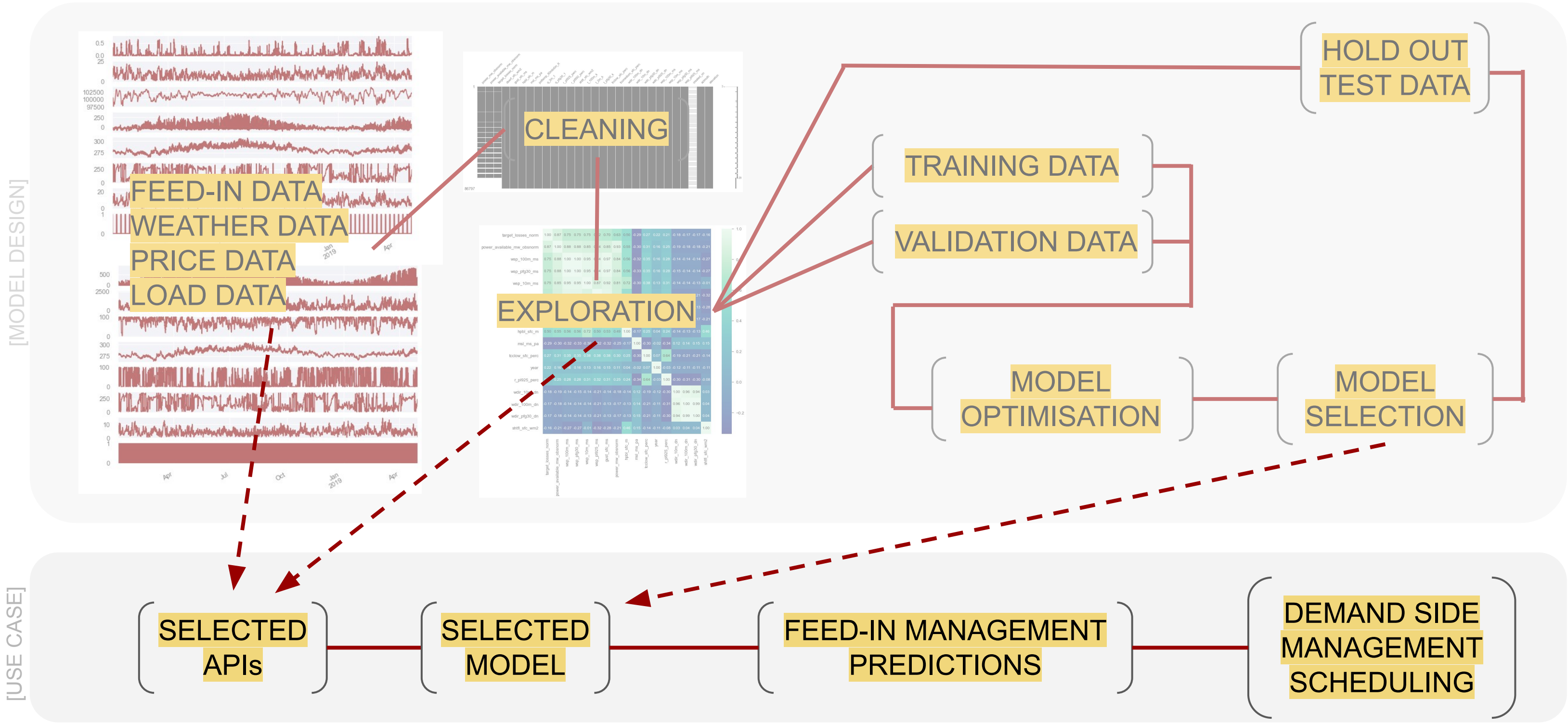
[MODEL DESIGN]
FEED-IN DATA
WEATHER DATA
PRICE DATA
LOAD DATA
CLEANING
EXPLORATION
HOLD OUT TEST DATA
TRAINING DATA
VALIDATION DATA
MODEL OPTIMISATION
MODEL SELECTION
[USE CASE]
SELECTED APIs
SELECTED MODEL
FEED-IN MANAGEMENT PREDICTIONS
DEMAND SIDE MANAGEMENT SCHEDULING

END.
QUESTIONS?

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