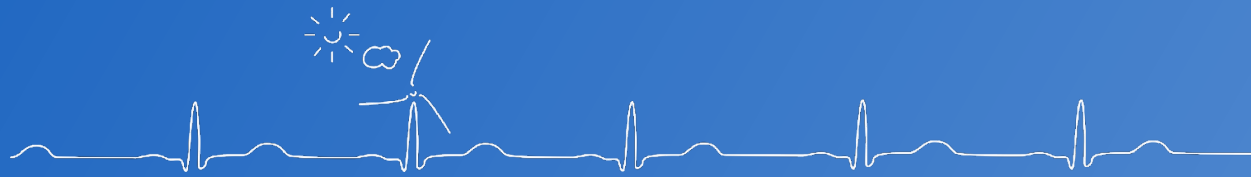
Foresight Power Trading

Machine Learning based forecasting for renewable energy trading

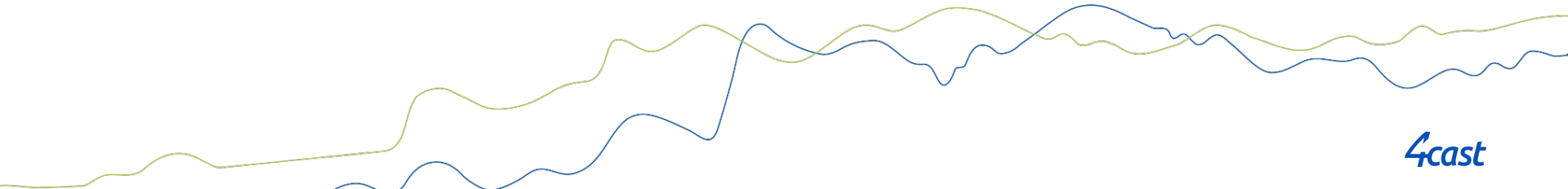


June 2023

Quick question

How much balancing costs can you save per month per 10 MW installed power with a solid forecast?

- 500€–1,500€
- 1,500€–4,000€
- 4,000€–8,500€
- 9,000€–14,000€



4cast – *heartbeat of renewables*

Financial balance for the energy transition

> “THE PRECISE LOOK INTO THE FUTURE – RENEWABLES BECOME CALCULABLE.”

Why forecasting RES for the energy market

Use your assets right

→ Weather driven energy generation

→ Uncertainty in yields with RES

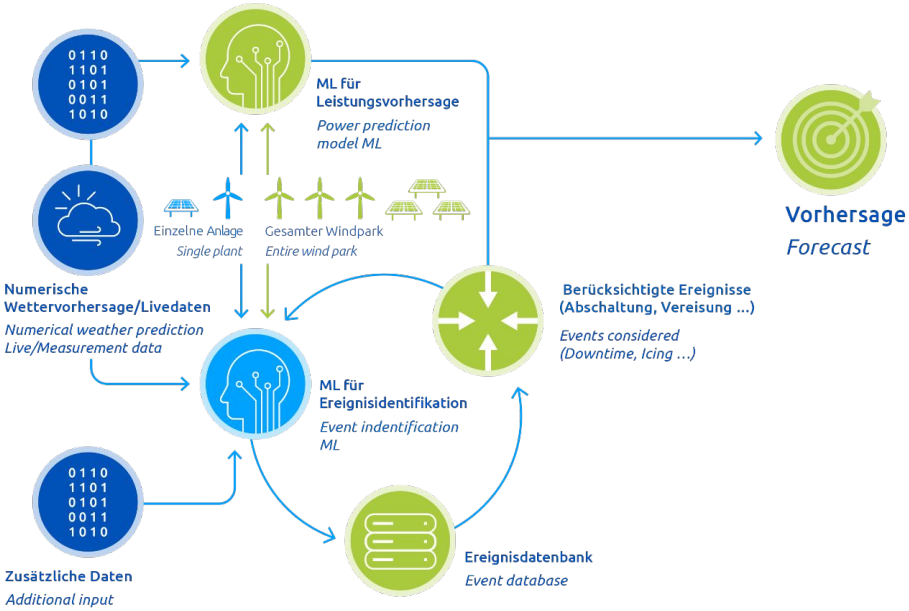
→ Volatility of energy prices

→ Balancing costs

→ Need for short-term trading decisions

Generating Forecasts

Data flow chart



Power yield forecasting
for wind and solar power

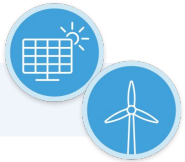
For various time horizons

- ➔ **IntraDay**
- ➔ **Day-Ahead**
- ➔ **Long-term predictions**

Importance of Data for Forecasting Quality

More Data – More Possibilities

Available (historical) production data	Possible model
No data	→ Physical model
Little data	→ Machine Learning model
Abundant data	→ Deep Learning model



The Models

Physical Model
Machine Learning Model
Deep Learning Model

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Physical Model

Based on mere physics

→ Simulating energy yield via physical laws

→ Realistic approximations

→ Experimental parameters

Park Specifics

Radiation on Module

Module Temperature

Wake Effects

Orography

Power Curve

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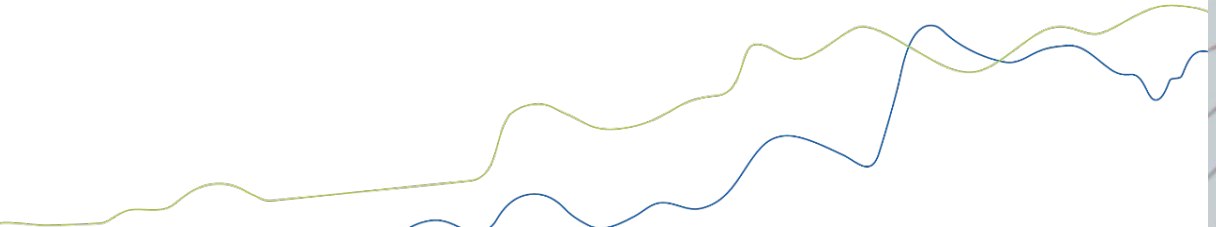
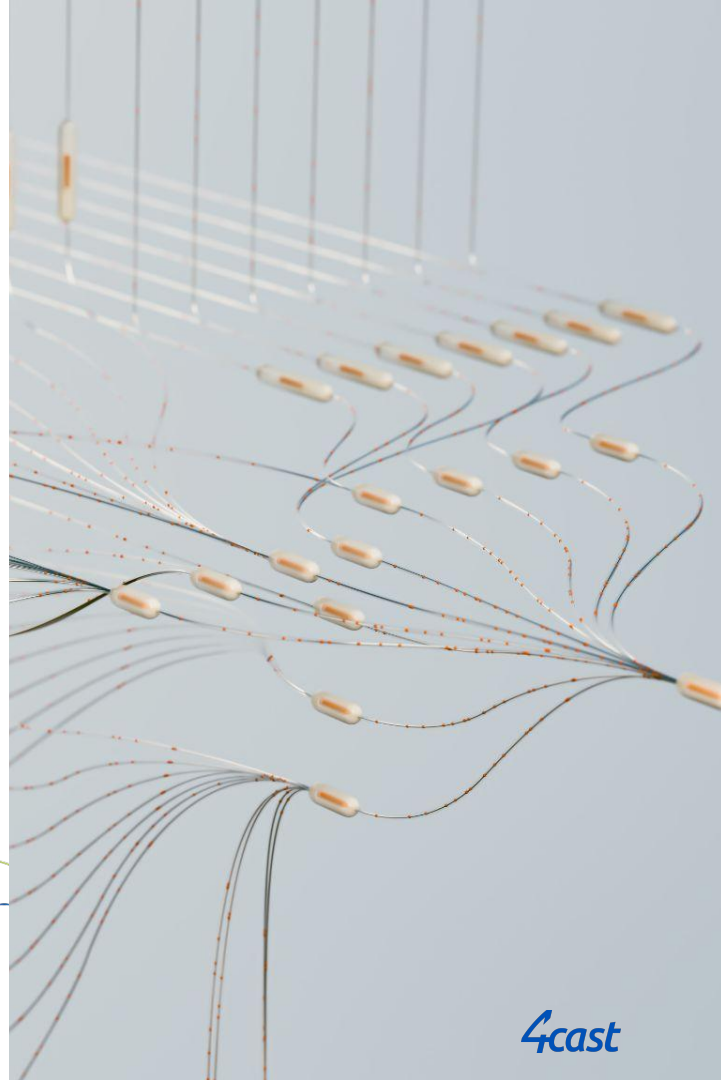
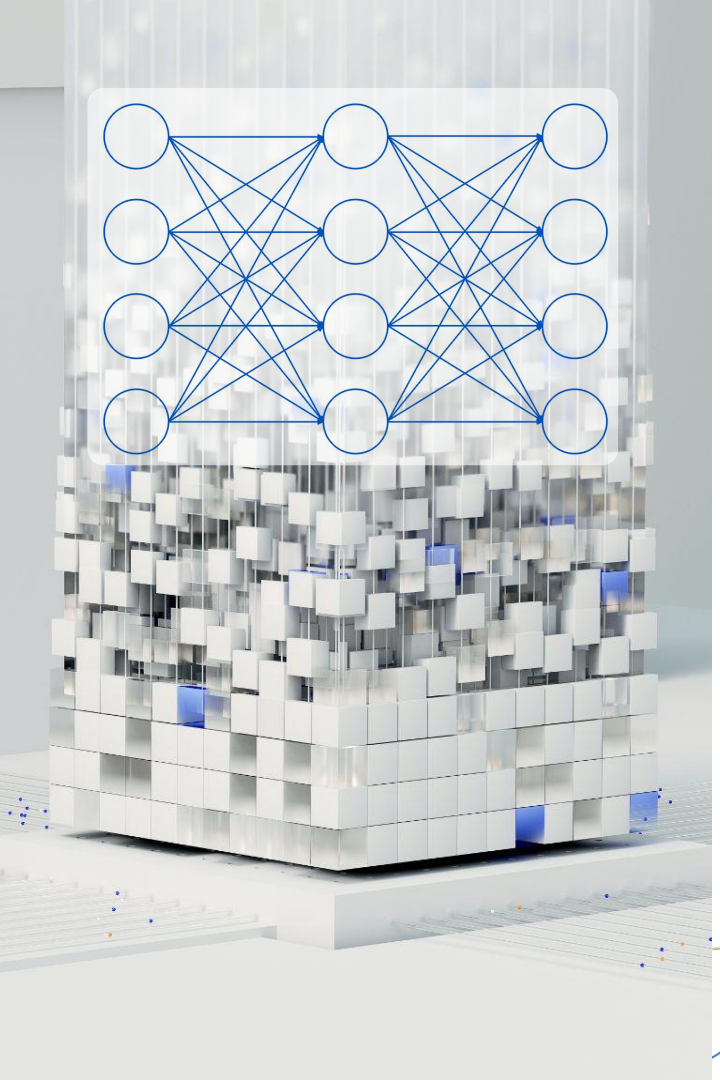
Machine Learning

Maps input to output

- → No Physics – but Statistics
- → Understanding Patterns in Data
- → Training relationship without memorizing
- → Model predicts future based on learned past
- → Vulnerable to changes in the real world







Deep Learning

Artificial Neural Networks

- → Originally subcategory of Machine Learning
- → Stems from deep hidden layers in artificial neural networks
- → Increase in computation power and data
- → Powerful models (GPT, BERT, etc.)
- → Able to understand temporal relationships
- → Data hungry

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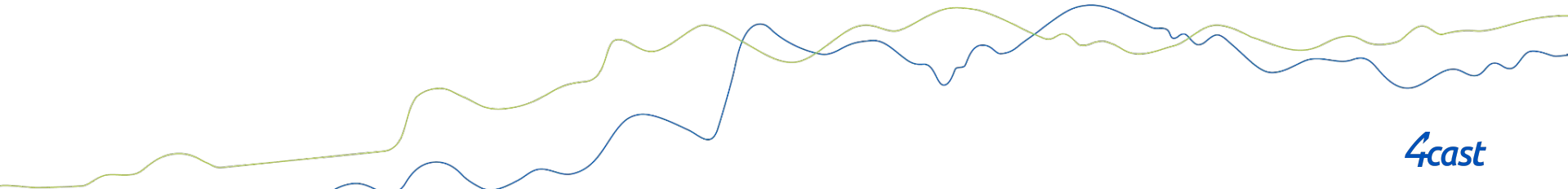
Evaluation metrics

Understanding forecast quality

$$\text{MAE} = \frac{\sum_t^n |\text{forecast}_t - \text{power}_t|}{n}$$

$$\text{Skill Score} = 1 - \frac{\text{MAE}_{forecast}}{\text{MAE}_{reference}}$$



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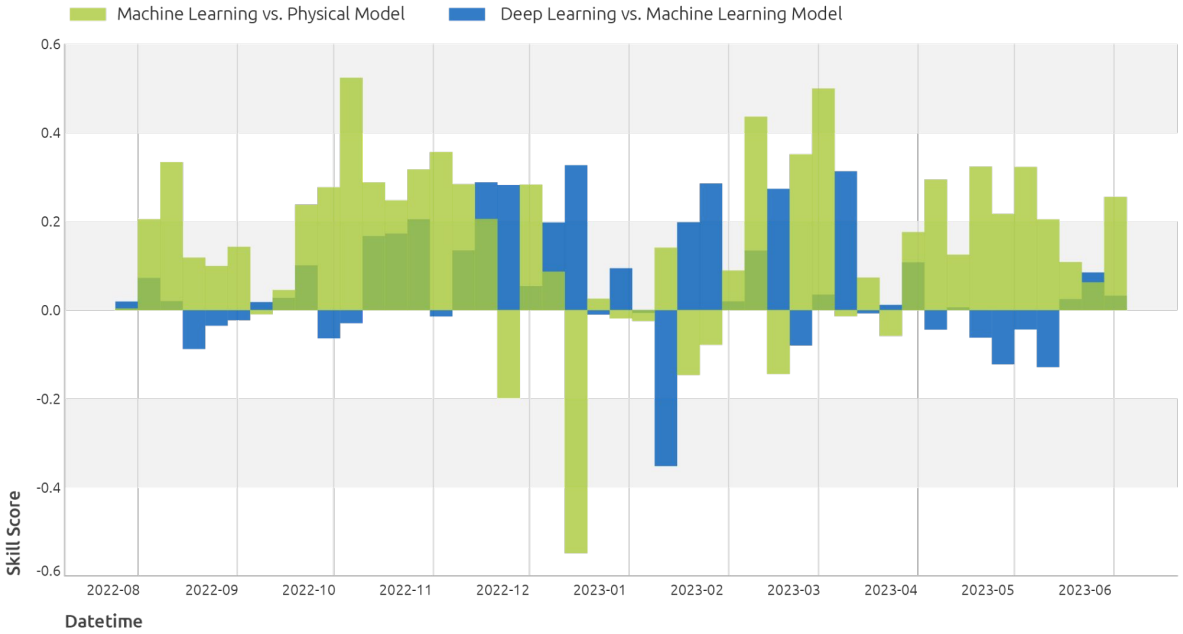
Result Solar Predictions

Skill Score, Financial Benefits



Balancing Costs in Germany* ~130 €/MWh

Installed Power: 1.7 MW

Financial Benefits

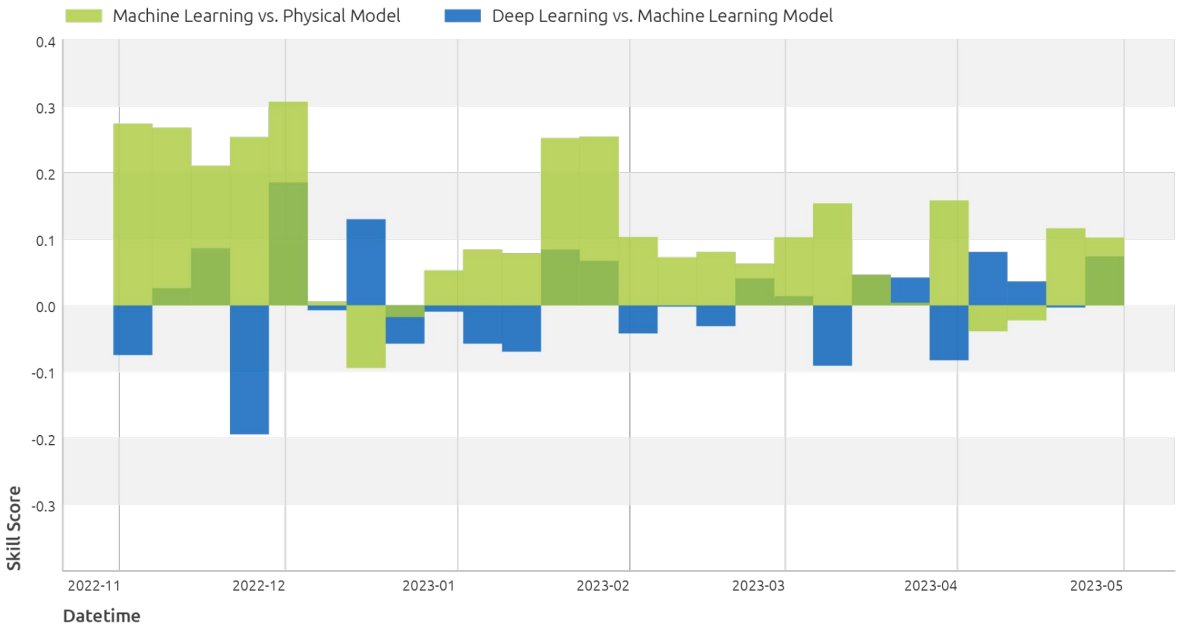
→ **Machine Learning**
→ **450 €/Month**

→ **Deep Learning**
→ **910 €/Month**

* 15min balancing energy price taken from www.smard.de.

Result Wind Predictions

Skill Score, Financial Benefits



Balancing Costs in Germany* ~130 €/MWh

Installed Power: 10.2 MW

Financial Benefits

→ **Machine Learning**
→ **9,050 €/Month**

→ **Deep Learning**
→ **14,050 €/Month**

* 15min balancing energy price taken from www.smard.de.


Weather Report
Deep Learning Prediction
imgflip.com

Thank you and meet us at our stand!

Let's connect on LinkedIn

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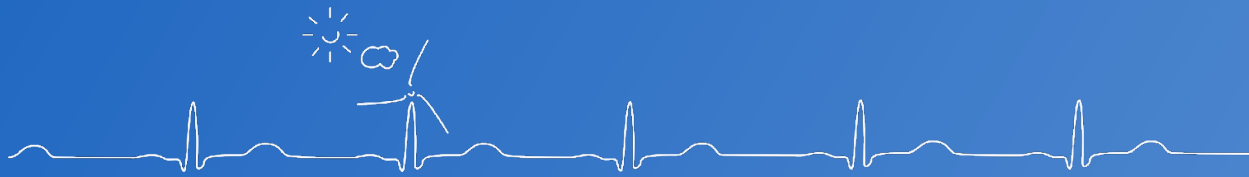


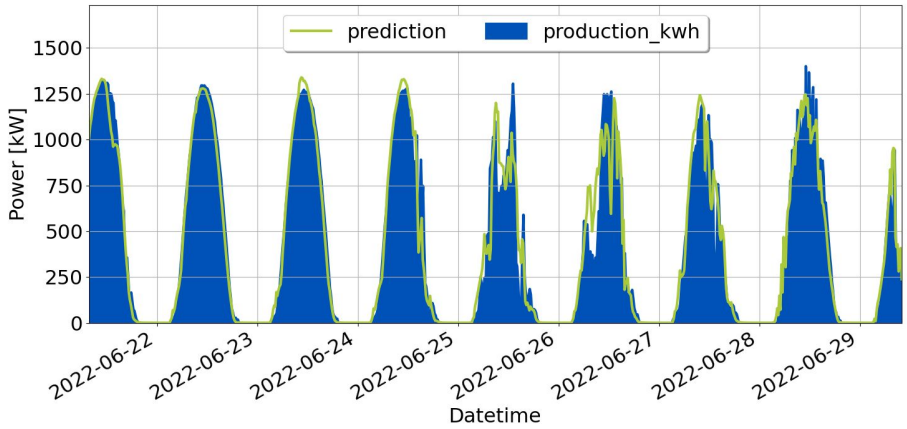
Backup

Example daily forecast – Germany

The described solar plant is located in Germany. We use in-house machine learning algorithms for this model. With an excellent database, we deliver very precise results.

The forecasts for this plant are delivered

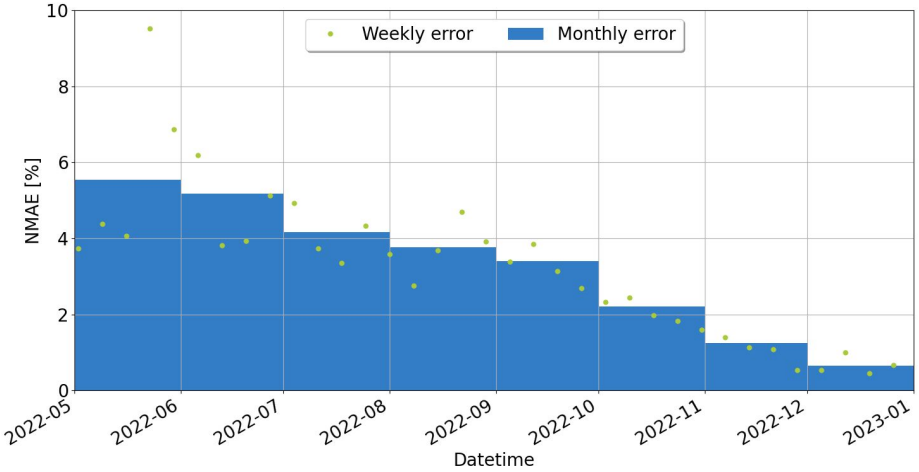
- ➔ every 15 minutes
- ➔ for 8 hours ahead and the forecasts themselves have a
- ➔ time resolution of 15 min.



Monthly Evaluation

The normalized mean absolute error (NMAE) is used for the monthly and weekly evaluation:

$$\text{nmae} = \frac{\Sigma \mid \text{forecast} - \text{power} \mid}{\text{Nominal Power}}$$



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Error Evaluation

The greater the time lag of the forecasts the greater is the error, which is shown in the figure.

Typical intraday forecasts are made for the next 15 minutes.