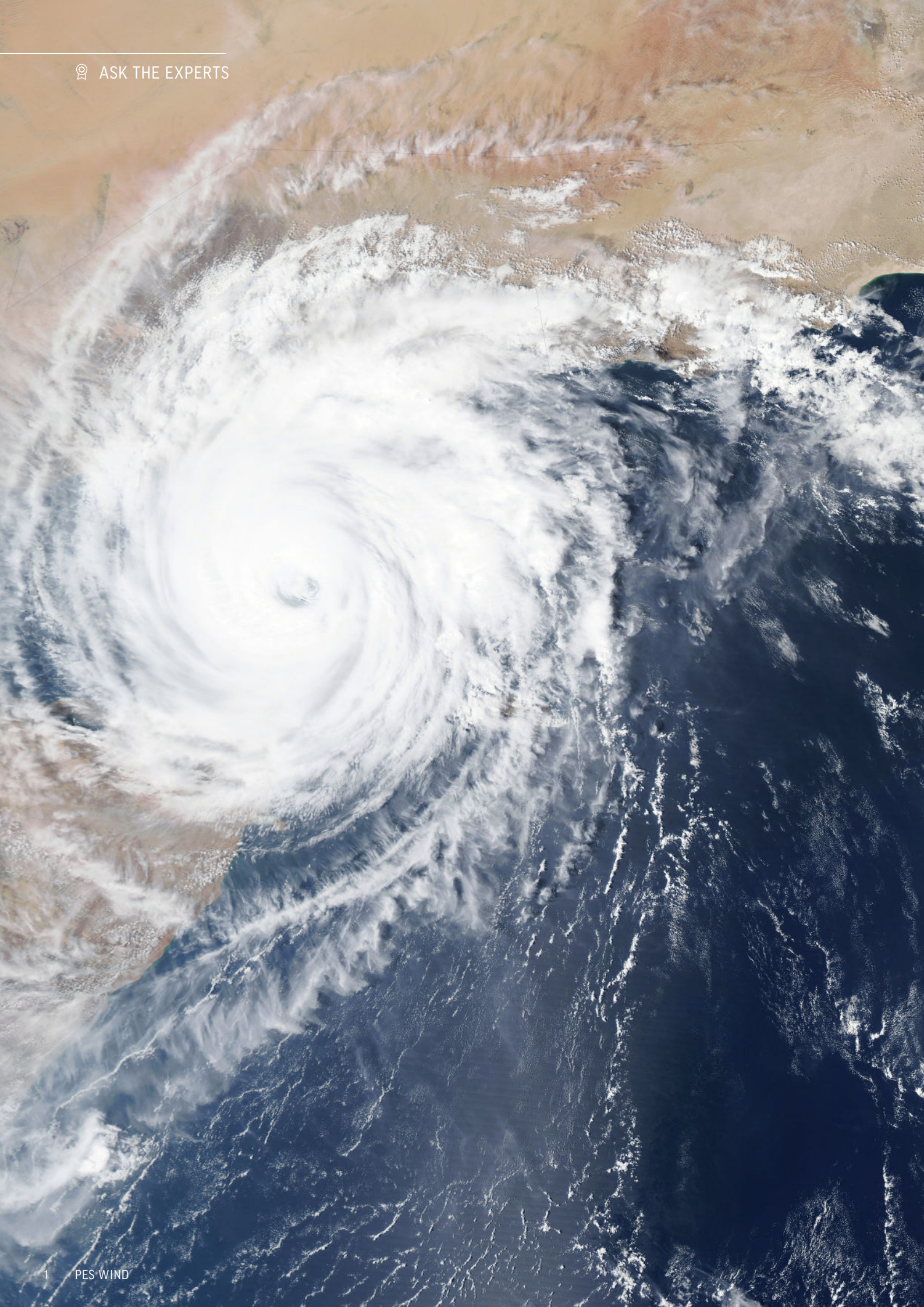


A powerful forecast

Competing in the energy market means selling your power before it is produced. How, therefore, do you ensure you can meet or exceed your projections by keeping your grid frequency constant? PES heard from Sascha Bauer, CEO at 4cast, about the power of technology to forecast the energy output from renewable energy power plants.

PES: It's great to speak to you Sascha. Perhaps we should begin with a brief introduction to 4cast, if we may?

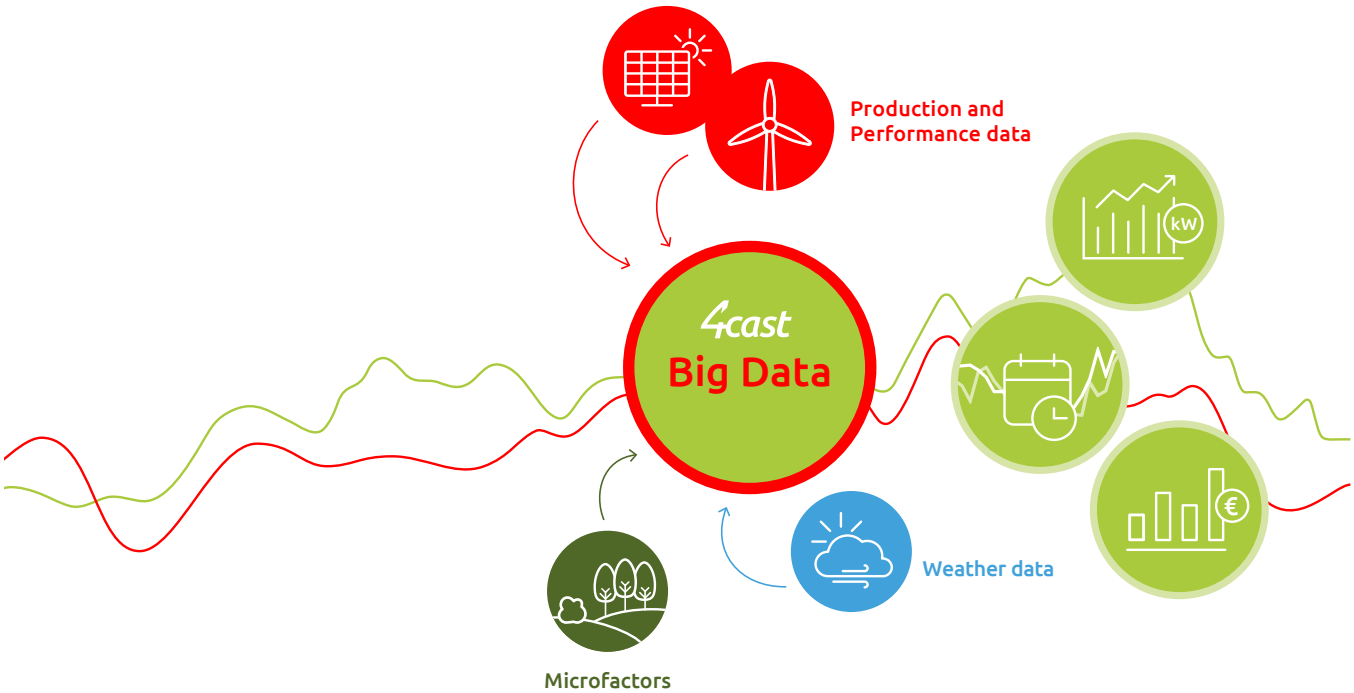
Sascha Bauer: Thank you very much for having us. 4cast is a joint venture of wind power pioneers and scientists. Our team competences range from physics, meteorology, data science to state of the art machine learning techniques. Currently, we focus our efforts on forecasting the energy output from renewable energy power plants, so far wind and solar, with consecutively increasing accuracy.

Furthermore, within the framework of the EU Maelstrom project, 4cast has a leading role in the development of software tools for a better work flow when using weather and climate forecasts based on machine learning techniques. In this regard, we work in close cooperation with the European Center for Medium-Range Weather Forecasts (ECMWF).

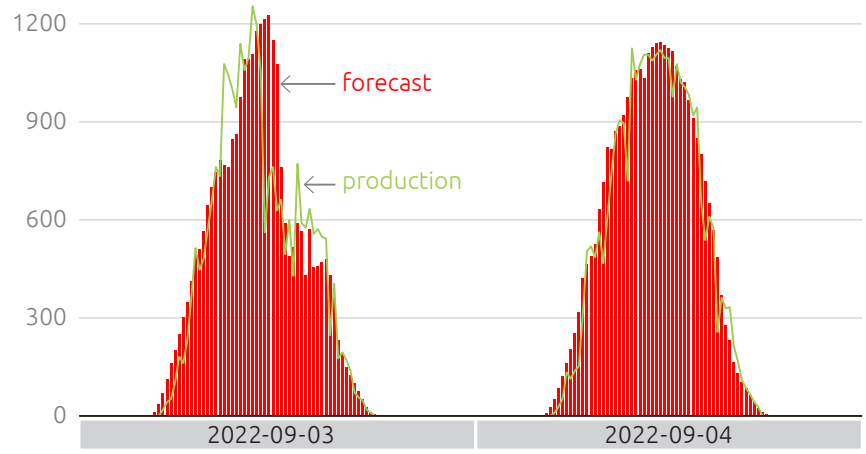
PES: So your focus, currently at least, is on energy yield predictions driven by your machine learning models, is that correct?

SB: That is correct, we have a specialized model for every purpose. First and foremost, every machine learning model needs input data. This training data consists of high resolution weather and historical production data of the respective power plants. We use a range of different model architectures each fitted for their designated objective. If at least one year of historical production data is provided, we train Boosting models. With additional live data input, we set up Recurrent Neural Networks (RNN). However, if there is no production data at all, for example if it is a new plant, we set up a physical model.

Sascha Bauer



Solar energy forecast example
power in kW



Regular retraining and continuous model updates are an integral part of our workflow.

Our motivation for these extended and ongoing efforts is simple. When societies aim to meet a large part of their energy needs from sources that are intrinsically fluctuating, precision in short and long term power output prediction becomes indispensable.

PES: What are the challenges that wind farm operators face in this regard?

SB: As a wind farm operator, you are naturally obligated to compete in the energy market. You always sell your power before it is produced. As you may know, keeping the grid frequency constant at 50 Hz leaves little room for error. If you cannot meet your expected output or overshoot, there will be fees and penalties to pay to transmission service operators who have to ensure power grid stability.

Therefore, knowing how much power is produced in the next 15 minutes, next hour or next day is crucial for a wind farm operator. Furthermore, knowing your energy yield gives you as an operator the opportunity to plan maintenance work more efficiently.

PES: How do your services aim to help?

SB: With our service we significantly reduce the process of plant micro management an operator usually has to go through. While the economic advantages of knowing your power output is immediately comprehensible, the devil is in the details. On paper, a certain wind speed leads to a certain power output of the turbine, in a functional relation called power curve, specific for the turbine model.

In practice, there are many factors that influence the actual power output next to the wind speed. Transmission service operators sometimes need to apply curtailments to prevent power grid overloads, leading to shutdowns of entire parks for a short period. Blades can collect ice in winter or official regulations for wildlife protection can also lead to the shutdown of plants. A turbine can be located in the wake of another turbine reducing power output, just to name a few examples. We adjust forecasts accordingly so that an operator does not have to worry and does not have to go through the time-consuming procedure of data post processing.

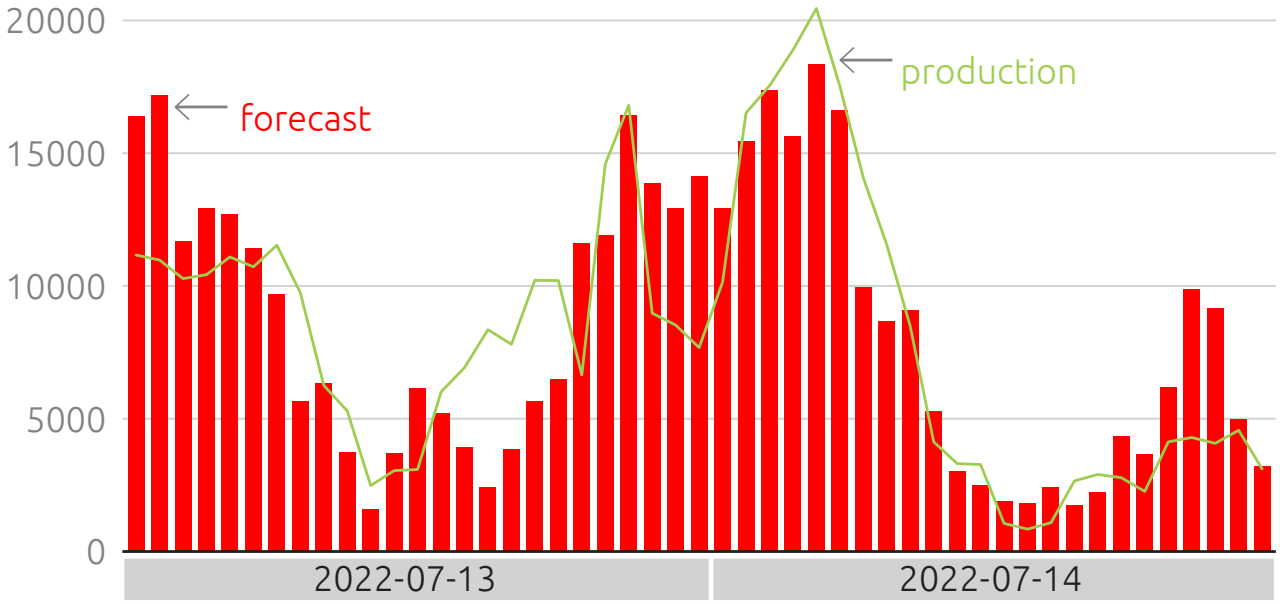
PES: Your approach relies on intelligent and adaptive algorithms, correct?

SB: Exactly, no model is determined forever and no model stands for itself. It is in fact one piece of gear in the forecast machine. For example, we closely monitor events that dampen power output and save the production data for training adaptive algorithms that help to identify these events in production data.

PES: This is a result of a lot of research over many years, isn't it?

SB: 4cast was founded in 2016 and we focussed our efforts mainly on research since then. Naturally, our expertise is built on the

Wind energy forecast example
power in kW



experience of our professionals and the latest scientific knowledge. We constantly keep learning from our insights to create ever more accurate forecasting models for our clients and a successful energy transition.

PES: Accuracy is of course important. How accurate are the results produced by 4cast?

SB: This is quite an important question. First we have to differentiate between solar and wind farm forecasts. Solar forecasts are usually more accurate, errors can go down to only 2% since less factors influence the outcome. Radiation is more predictable and less chaotic than wind speed. For wind farms, accuracy depends highly on the complexity of the local topography and also on the quality of production data provided by operators or owners. A measure of thumb for the expected error is around 10% to 12%.

PES: In fact, you claim 'absolute precision'. How is that made possible?

SB: Absolute precision is naturally not to be mistaken with 100% accuracy and 0% error, which is impossible. It means we absolutely do not compromise in pushing for precision in our own models, in our work and in the aim for customer satisfaction.

PES: What kind of elements does your data take into account, that normal weather forecasts don't? I'm thinking in terms of the terrain, surface conditions, vegetation or neighboring systems in a park?

SB: We use specialized weather data with a much higher spatial resolution than usually used for a typical weather forecast. This data includes wind speed and direction in many layers above the surface. Furthermore, we take wake effects from neighboring turbines and therefore lower wind speeds into account. Our machine learning algorithms help us to identify events in historical or live production data to assert a higher level of precision.

PES: How far ahead are you able to forecast?

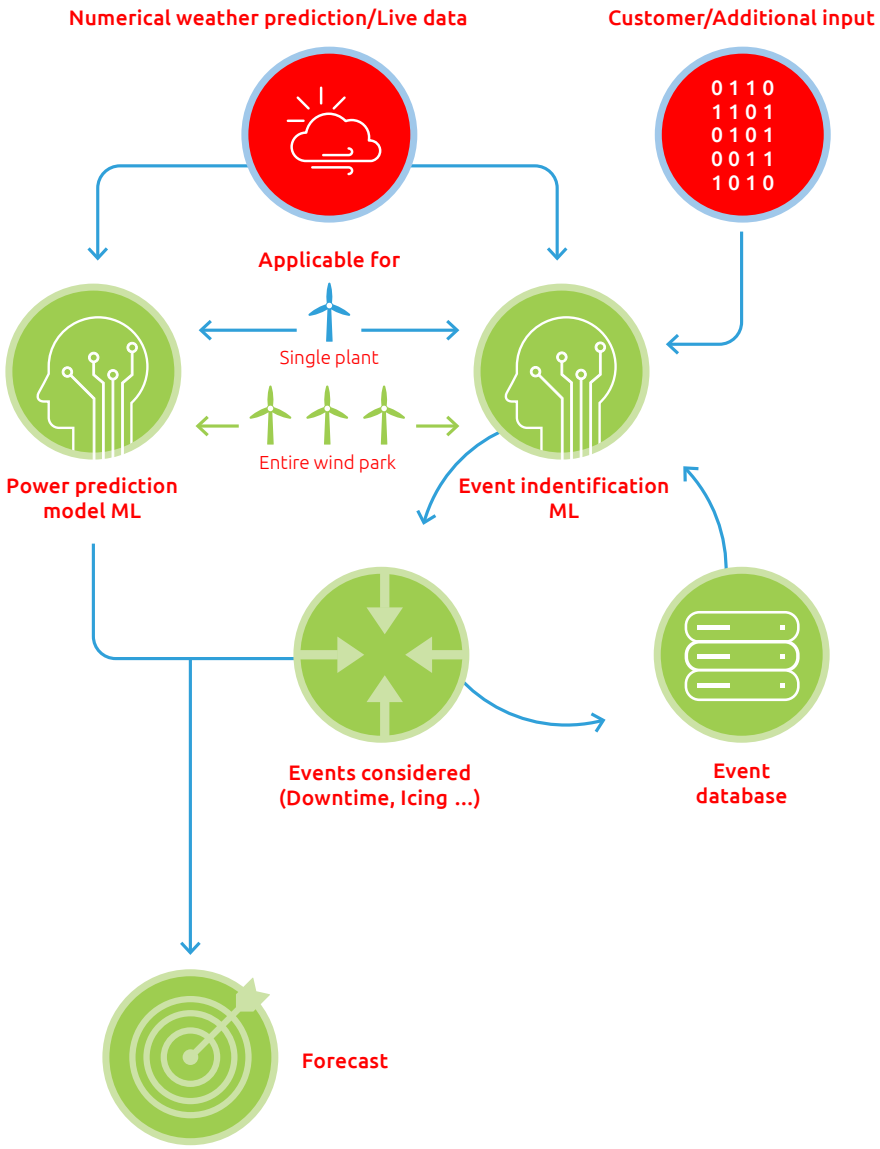
SB: Precision naturally declines the further ahead you predict. We offer forecasts up to 4 days into the future, after that, weather prediction data intrinsically gets uncertain to be a reliable base for power forecasts. Weather is a chaotic system and its predictability is limited.

PES: Is it possible to apply the forecast to individual facilities, as well as an entire wind park?

SB: Yes, it is entirely possible. Just let us know your purpose and we will be able to provide 15 minutes power output for individual facilities or entire wind farms.

PES: In summary, then, what are the main advantages of this type of forecasting?

SB: The main advantage here is the customizability. A forecast optimized by even a few percentage points will save you several thousand euros. This paves the way for more reliable day-ahead contracts and improved sales planning for the market. When focussing strongly on machine learning approaches you can also minimize the potential human error.



The ability of algorithms to identify patterns in observations, in combination with their scalability, surpasses the working capacity of any human being. Let me emphasize this point by an illustration. Machine learning models playing chess have been trained by masters of chess and with numerous training cycles as well as constant fine tuning. Now these models beat any grandmaster of the game. In fact one single algorithm beats a thousand grandmasters in a thousand different games simultaneously when provided with enough computing power.

PES: Is this the future of forecasting for the wind industry do you think? Is there more to come, from 4cast in particular?

SB: As you may have noticed in the prior analogy, chess is a finite game with clearly defined rules. In an environment like this, machine learning approaches are superior. But machines can not draw out borders and derive the rules. This task still falls into human competence.

To keep an overview over a complex situation with growing demands, translating and fitting it into a finite system a machine can operate, is the challenge we face at 4cast for the renewable energy sector. For this regard we aim to identify and include more data sources and any small factor that exerts an influence on the output of the plants.

We aim to make processes independent from error sources like rogue or coarse-grained data, improve weather data downscaling and human communication aspects. We believe in giving our customers a software solution that has no vulnerabilities. For this we have the grandmasters of the game in our team.

https://4-cast.de