N-SIDE

WEBINAR

Forecasting & managing system imbalance: case studies & lessons learned

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CONTEXT

European balancing is changing

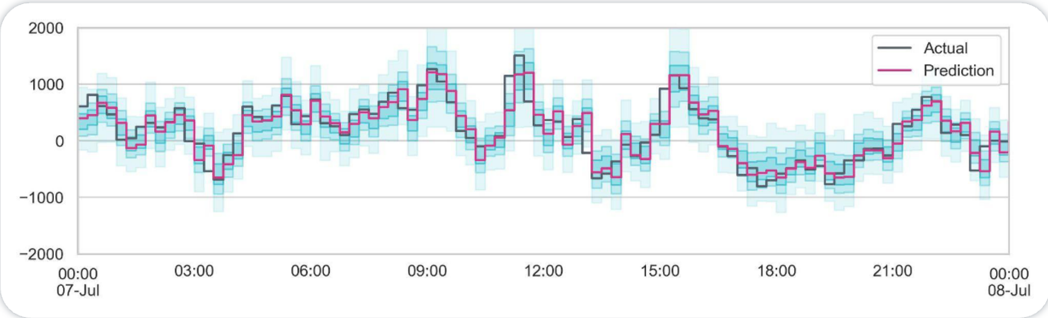
- We can already see how increasing penetration of variable renewable energy resources increases imbalance's size and volatility. Complex new pan-European balancing markets such as MARI and PICASSO add a layer of uncertainty to future operations.
- The changes will affect different countries differently. For example, smaller countries might see large changes, while larger countries might not notice much of a difference.
- Most TSOs are reticent about these changes and how they will impact their operations. Different TSOs might use the platforms differently depending on local balancing philosophies, market dynamics, and available assets. This will in turn shape local regulation and price formation.

Agility will be vital for balancing forecasts going forward

- We expect a certain decoupling of the balancing energy price (bid by the BSP) and the imbalance price (cleared by e.g. MARI, modified by the TSO). This could impact market participant behaviour which could impact imbalance volumes. We expect some regulation and/or TSO-level price formation to steer such behaviour.
- Unlike other fundamental market changes such as the implementation of flow-based coupling, there will not be a step-change in balancing markets where things change drastically all at once and be stable afterwards. The balancing world, and therefore forecasts, will have to continue to evolve for the foreseeable future.
- Country-level balancing forecasts will need to take cross-border factors into account, but regional specificities will not disappear. There is no one-size-fits-all solution, and the necessity of market insight for accurate forecasting will only become more pronounced.

3 key takeaways

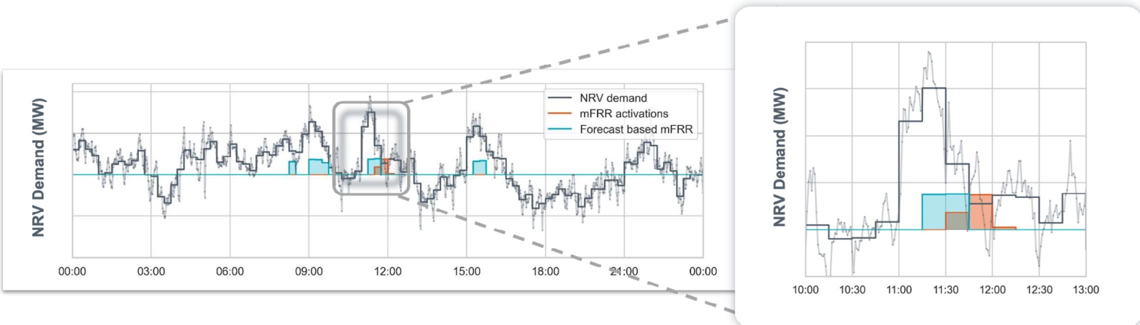
1 Accurate probabilistic forecasting can improve mFRR activation



We don't forecast to forecast; we forecast to decide.

By identifying the imbalance forecast TSO decision as mFRR activation (when and how much to activate), we can provide a tunable decision support tool to the operator. He or she can decide

- At what threshold to start activating mFRR,
- What the risk of crossing the threshold should be,
- How much mFRR to activate to control counter-activation risk?



2 Dynamic Reserve Dimensioning can decrease costs and increases security of supply

The purpose of dynamic dimensioning is to achieve a certain level of reliability by adapting the sizing of reserves to the conditions of the system, as they are estimated at the moment that a sizing decision is being made. The intuition is that we can adapt the amount of reserve to the anticipated risk in the system: days with riskier conditions (e.g. high load forecasts or high renewable generation forecasts) can carry more reserves, and days with less risky conditions (e.g. low load forecasts or low renewable generation forecasts) can carry fewer reserves.

Several benefits are observed when adapting the reserves dynamically:

- It allows us to achieve a more consistent degree of risk exposure in the system *(whereas with static dimensioning we tend to be overprotected in low-risk periods and under-protected in high-risk periods),* and
- It allows us to achieve our target reliability level with less reserve capacity on average, resulting in lower procurement costs for the System Operator.

Note, however, that objectives (1) and (2) compete with each other and the right balance can be tuned while developing the right model for the right system.

3 Successful forecasting requires skillful implementation

There are several questions you should ask when implementing a forecaster in your operations:

Value creation:

What decision needs to be taken using the forecast output? What would success look like for the forecasting system? Can the business objective be coded into the algorithm itself? Can you sketch the upstream and downstream business processes?

People: basic management for advanced automation

Who are the stakeholders? Which ones are you missing? Have you obtained their buy-in? Have you identified all the roles and assigned them clear and distinct responsibilities? How will you ensure business continuity?

Data: security of supply

You have the data for the PoC, but is it ready for production? Are the pipelines stable? Do you have a plan for ensuring feature persistence?

Software

- **Security: follow the standards**
  Is the organization ISO 27001 compliant? What standards are followed when building the software itself? Are the systems pen tested?

- **Reliability: Software engineering, not data science**
  How are the data and performances monitored? How is the CI/CD pipeline built? Is the architecture implemented by the data scientist, or by software engineers?

- **Accuracy is a system-level property:**
  Besides a proven algorithm, does the platform have different features that enhance forecast accuracy, such as transparency dashboards, probabilistic forecasts, or scenario models? What automatic processes have been implemented to ensure accuracy, such as monitoring, cross-validated backtesting, hyperparameter tuning, and experiment management?

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Questions answered by our experts

How do you ensure that BRPs do not react on activation of mFRR by the TSO, or apply a similar forecast tool? In other words, are the results (with the blurred numbers) realistic in this respect?

It depends on the regulatory environment and when the imbalance prices are published - in some environments it is seen as desirable that BRPs react, and in others, it is not. Where it is encouraged and the effect can be seen (Belgium being one example), the implicit reaction should be modelled. To preserve client confidentiality, we do not want to expand too much on the regulatory environment for which the case study was done. However, based on previous experience with building realistic simulations which match real-world behaviour, we can say that such considerations were accounted for and are cautiously optimistic that the numbers are realistic.

The system imbalance is also impacted by changes in production programs (mainly big units) on the system. Are you including (or able to include) this kind of information?

It is true that switching large units on or off creates significant imbalances because the ramping around the switching time cannot fit perfectly into the market time units. If the unit operator is part of a large aggregator or BRP, such imbalances can be balanced by other resources in their portfolio, but this is not always the case. We then see large imbalances, most often on the hour, e.g. at 15:00 but not so much at 15:15. There are also planned outages e.g. of nuclear plants which have publicly available information which we mine, although these events are much less frequent.

Most of the information on production programs of e.g. gas plants is not known at the time when most of our forecasts need to be made (depending on the forecast, and to our knowledge). Our forecasting platform uses direct and derivative features which account for published events and anticipate approximately when unpublished ones would take place. We believe that we are capturing much of the available information for use in the forecasts, but this is an aspect of imbalance forecasting more broadly where the potential for forecast precision improvement exists.

In a future where SI forecasts affect imbalance volumes themselves, how do you expect to evaluate the quality of forecasts?

This is a well-known problem in the implicit/reactive balancing field and one we will not presume to solve fully here. As we understand it, the problem is that an imbalance value is forecast, but the imbalance that is realised is different. This is by design because the market is expected to react to the imbalance price which is based on the forecast, to reduce the imbalance. Therefore, measuring the accuracy of the forecast is difficult because the 'actual' imbalance against which its accuracy is measured, does not exist. The second problem is how to train a model to predict this reaction-free system imbalance, given that all the past imbalance values (training data) will reflect the market reaction.

What we can say based on our experience with similar problems is that it might be necessary to reformulate the problem in different terms. More useful results might be obtained by not thinking of the problem in terms of a forecast of a value that is never realised, but rather some other formulation.

Which methods/tools are generally used for the forecasts e.g. for the RES forecast error and how is it updated for the next time step?

Various classes of algorithms are used in production systems. At the moment, tree-based methods, classic regression, and some neural network models are popular in industry. There are other tools and methods which also play a role, such as feature selection, but the most important accuracy improvements come from feature engineering, which in turn comes from subject matter expertise.

Updating for the next time step depends on the algorithm and data availability. For many forecasts such as day-ahead ones or even near-real-time imbalance forecasts, the values from the previous time step are not available when the next period needs to be forecast. In such cases, regression-style models which treat the time steps as separate are often more effective than time series forecasting techniques.

Can you share metrics on your SI forecast accuracy?

We have found that the accuracy that can be expected of forecasts, differs for different countries. It also depends on the use case and the goal of the forecast. We have found that it is critical to understand how the forecast is going to be used (what decision needs to be made). Accuracy is very important, but having an extremely accurate forecast of almost-the-right-value, is often less useful than having a good forecast of exactly the right value.