# ALPACA Forecasting Tool Description

for Establishing an
aFRR Balancing Capacity Cooperation based on the Probabilistic Method according to Art 33(6) EBGL

| Version | Short description | Date |
|---|---|---|
| **1.0** | Go-live version | 30. 7. 2025 |
| | | |

## Glossary and definitions

| Abbreviation | Description |
|---|---|
| **aFRR** | Automatic Frequency Restoration Reserves |
| **ALPACA** | Allocation of Cross-zonal Capacity and Procurement of aFRR Cooperation Agreement |
| **AT / CZ / DE** | Country codes: Austria / Czechia / Germany |
| **ATC / CZC** | available cross-zonal capacity after the intraday cross-zonal gate closure time |
| **ARL** | Acceptable Risk Level |
| **BC** | Balancing Capacity |
| **CORE** | One of the European capacity calculation regions |
| **CPOF** | Capacity Procurement Optimisation Function |
| **EBGL** | Electricity Balancing Guideline |
| **FOX** | Forecasting tool |
| **IEL** | Initial Exchange Limit |
| **IGCC** | International Grid Control Cooperation (IN-platform) |
| **PICASSO** | Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation (aFRR-platform) |
| **PV** | Photovoltaic |
| **ProbM** | Probabilistic Methodology according to Art 33(6) EBGL |
| **TIGER** | Forecasting tool |
| **TSO** | Transmission System Operator |

## Content

# 1. Introduction and Summary

ALPACA applies on the borders of Austria to Czechia and Czechia to Germany the probabilistic method based on Art 33(6) EBGL, which allows a cross-border balancing procurement based on a probability calculation of available cross-zonal capacity (CZC / ATC) after intraday cross-zonal gate closure time.

Therefore, two Forecasting Tools (FOX, TIGER) were developed. Both Forecasting Tools assess the following risks:

- (Risk 1) The risk of unavailable CZC due to un/planned outage or congestion, i.e., the probability that available CZC is lower than the procured balancing capacity at the respective border;
- (Risk 2) The risk that the local balancing energy demand cannot be covered with locally procured balancing capacity;
- (Risk 3) The risk of insufficient reserve balancing capacity due to unavailability of CZC, i.e., the probability of an area's aFRR demand (balancing energy) being above a certain value of local procurement and at the same time not enough CZC is available to access cross-border procured balancing capacity to meet this aFRR demand.

Potentially mitigating effects are not taken into account in the forecasting, e.g.,

- the effect of imbalance netting via IGCC or PICASSO on actual aFRR activation required to cover aFRR demands using a larger set of borders;
- the possibility to access aFRR via PICASSO using multiple borders (e.g. DE accessing a bid in CZ via AT);
- the possibility to use other aFRR bids submitted to PICASSO from different areas or the same area to cover an area's aFRR demand.

In the forecasting process, a forecasting algorithm will estimate the probability of available CZC being equal to or lower than various scenario values or forecasting ranges.

The forecasting ranges are defined by the ProbM border per product (negative/positive) and go from 0 to 100 MW per direction and border. The increments between each scenario shall be set up by each Forecasting tool individually.

The forecasted probability presents an estimate for the risk of unavailable CZC due to un/planned outage or congestion (Risk 1) for a given scenario value. Combining this risk with the risk that the local balancing energy demand cannot be covered with locally procured balancing capacity, due to the unavailability of the cross-border procured volume (Risk 2) yields an estimate of the risk of insufficient reserve capacity (Risk 3), i.e. the probability that the actual available CZC is lower than the forecasted available CZC multiplied by the probability that the forecasted value of cross-border procured capacity is needed to satisfy local aFRR demand.

TSOs will determine acceptable risk values for the risk of unavailable CZC (Risk 1) and the risk of insufficient reserve capacity (Risk 3). Those values will enter the risk assessment in which the initial exchange limit will be determined in such a way that these limits respect the acceptable risk chosen by TSOs, while choosing the largest forecasted scenario value. In other words, acceptable risks for Risk 1 and Risk 3 filter all scenarios per border, direction, product and 4h-block to receive the maximum possible amount of exchange under the defined maximum risks. This value is the Initial Exchange Limits (IEL) and is used as an input for the Capacity Procurement Optimisation Function (CPOF).

Each forecasting tool will perform the calculation of 48 IEL values every day. There is a value calculated for each border (2), direction (2), product (2) and 4h-block (6).

The following document provides further insights into this process. Chapter 2 provides information on the inputs used by the forecasting tools and the outputs they provide. Chapter 3 gives a detailed explanation of the processes these tools apply. Chapter 4 describes how the outputs of multiple forecasting tools are processed to provide a single Initial Exchange Limit, which sets the upper limit of aFRR that the CPOF may procure abroad for a given country.

## 2. Description of Data Points

### 2.1. Inputs for FOX

| Data Point | Description |
|---|---|
| **aFRR Balancing Energy Demand** | Volumes of aFRR balancing energy demands, which were sent to PICASSO/IGCC: |
| **Dimensioned aFRR capacity Demand** | Dimensioned the aFRR balancing capacity demand as used in the respective allocation optimisation |
| **ATC** | Available Transmission Capacities (available CZC) |

### 2.2. Inputs for TIGER

| Data Point | Description |
|---|---|
| **Dimensioned aFRR Demand** | Dimensioned the aFRR balancing capacity demand for DE, AT and CZ. |
| **aFRR Balancing Energy Demand** | Volumes of aFRR balancing energy demands, which were sent to PICASSO/IGCC for DE, AT and CZ. |
| **Vertical Grid Load Forecast** | Forecast of the expected vertical grid load in the 50Hertz Control Area. |
| **Temperature Substation Röhrsdorf** | Forecast of a specific temperature at the 50Hertz Substation UW-Röhrsdorf. |
| **Total Load Forecast** | Forecast of the expected load for DE, AT, CZ and the four German control areas. |
| **Wind Generation Forecast** | Forecast of the total expected wind generation for DE, AT, CZ and the four German control areas. |
| **PV Generation Forecast** | Forecast of the expected PV generation for DE, AT, CZ and the four German control areas. |
| **CORE Refprog** | Forecasted Exchanges between the CORE Bidding Zones. |
| **CORE Vertical Load** | Forecast of the load for every Bidding Zone in the CORE region as seen from the transmission grid. |

| Data Point | Description |
|---|---|
| **CORE Generation** | Forecast of the expected total generation per BZ in the CORE region. |
| **CORE Net Position** | Forecasted Net Position for every Bidding Zone in the CORE region. |

## 2.3. Outputs of both Forecast Tools

| Data Point | Description |
|---|---|
| **IEL FOX** | Maximum amount for exchange of balancing capacity according to ProbM FOX. |
| **IEL TIGER** | Maximum amount for exchange of balancing capacity according to ProbM TIGER. |

# 3. Forecast Tool Algorithm Description

## 3.1. FOX

On each calendar day, between 06:00 and 08:00, for an affected delivery day, an IEL is determined per border, direction, product, and 4h-block.)

In order to receive the IEL, the risk calculation is performed for each scenario (0-100 MW in 5 MW increments), $MW_{prod}^{procured\ XB}$. The risks are calculated based on ex-post data from the previous 8 weeks, starting from D-2.

### 3.1.1. Risk Calculation

**Data**

Since the data covers the previous 8 weeks starting from D-2, a weighting of the datapoints of all datasets is done.

Before calculation, the data is filtered by 4h-block, border, direction, and product. Therefore, the data used consists of, e.g., the respective values from the second 4h-block (04-08 am), AT-CZ, aFRR+ from the previous 8 weeks.

**Calculation Steps**

1. Calculation of the risk that CZC is unavailable due to un/planned outage or congestion (Risk 1), $r_{dir}^{unavCZC}$

$$r_{dir}^{unavCZC} = \frac{\sum Intervals_{\ 15min\ in\ 4hblocks}\left(CZC_{dir,15min} < MW_{prod}^{procured\ XB}\right)}{\sum Intervals_{\ 15min\ in\ 4hblocks}(all)}$$

   This measures the average ex-post risk of having insufficient or no available CZC, $CZC_{dir,15min}$, on the respective border and direction. This risk covers the probability that the TSO may not have been able to use the volumes procured cross-border, $MW_{prod}^{procured\ XB}$, when needed.

Since the available CZC is given in a 15-minute resolution, the calculation is based on this interval.

2. Calculation of the risk that the local energy demand cannot be covered with locally procured balancing capacity (BC), due to the unavailability of the cross-border procured volume (Risk 2), $r_{product}^{Pdem}$

$$r_{prod}^{Pdem} = \frac{\sum Intervals_{\ 4Sec\ in\ 4hblocks}(|Dem_{prod}^{PICASSO}| > (|BC_{prod}^{dimensioned}| - MW_{prod}^{procured\ XB}))}{\sum Intervals\ (all)_{4Sec\ in\ 4hblocks}}$$

This calculation assesses the risk of the local energy demand, $Dem_{prod}^{PICASSO}$, being higher than the locally procured balancing capacity. The locally procured balancing capacity is calculated by subtracting the cross-border procured volumes from the dimensioned balancing capacity, $BC_{prod}^{dimensioned}$, for this period.
Since the demand is given in a 4-second resolution, the calculation is based on this interval.

3. Calculation of the forecasted risk that reserve capacity is insufficient due to the unavailability of CZC (Risk 3)

$$r_{dir,prod}^{insuff} = r_{dir}^{unavCZC} * r_{prod}^{Pdem}$$

This risk combines both the risk of unavailable CZC and high demand and therefore covers the worst-case situations, when the cross-border procured balancing capacity is not available but needed in order to cover local aFRR demand.

The calculation of the risk values and an individual assessment of each risk are done per scenario, border, direction, product and 4h-block (see Chapter 4).

## 3.2. TIGER

### 3.2.1. Forecasting Method

TIGER calculates the three different risks for each border, direction, product and 4h-block, according to Art. 4(4) of the proposal pursuant to Art. 33(6) EBGL:

1. Risk 1: The risk of unavailable CZC ($r_{dir}^{unavCZC}$).

TIGER calculates$r_{dir}^{unavCZC}$ using a machine learning algorithm (gradient-boosted trees), which predicts the risk of unavailable CZC based on exogenous data such as forecasts of electricity generation by wind or PV (see chapter 2). There is a separate algorithm for each border and direction. The scenarios considered by TIGER are all 5 MW increments between 0 MW and 100 MW. The machine-learning algorithm calculates Risk 1 for the 100 MW scenario. For the 0 MW, the risk of unavailable CZC is always set to be 0 %. The remaining 19 scenarios from 5 MW to 95 MW are calculated by applying a risk reduction factor to the value of Risk 1 calculated for the 100 MW scenario.

This risk reduction factor $r^{reduction}$ is calculated by assessing all the share of instances in the last year, in which the available CZC is larger or equal to 5 MW and lower than 100 MW in This value is divided by 19 to attain the risk reduction factor $r_{scenario}^{reduction}$:

$$r_{scenario}^{reduction} = \frac{r^{reduction}}{19}.$$

Multiples of the risk reduction factor $r_{scenario}^{reduction}$ are then subtracted from $r_{dir,100MW}^{unavCZC}$ to attain $r_{dir}^{unavCZC}$ for the scenarios between 0 MW and 100 MW.

2. Risk 2: The risk that local demand within a country cannot be satisfied by locally procured bids ($r_{prod}^{Pdem}$).

This probability details the likelihood that an affected country requires more than the nationally procured aFRR to satisfy their demand for each scenario, thereby relying on the aFRR procured abroad to satisfy their aFRR demand. It is calculated with the help of three inputs:

- The cumulative distribution function of aFRR (balancing energy) demand $Dem_{prod}^{PICASSO}$ for the affected country.
- The dimensioned aFRR demand for the affected country $BC_{prod}^{dimensioned}$.
- The capacity value of each scenario $MW_{prod}^{procured\ XB}$.

The cumulative distribution is calculated based on $Dem_{prod}^{PICASSO}$, for each country. It is based on the aFRR activation demand of the last 12 months and is updated every 6 months. The risk $r_{prod}^{Pdem}$ is calculated by evaluating the value of the distribution function at the balancing capacity value representing the locally procured aFRR bids $MW_{prod}^{procured\ locally}$. It is calculated as follows:

$$MW_{prod}^{procured\ locally} = BC_{prod}^{dimensioned} - MW_{prod}^{procured\ XB}$$

3. Risk 3: The risk that reserve capacity necessary to satisfy local aFRR demand is not available due to unavailable CZC ($r_{dir}^{insuff}$).

This risk combines both the risk of unavailable CZC (Risk1) and high demand (Risk2) and therefore covers the worst-case situations, when the procured CZC is not available however needed in order to cover local energy demand.

$$r_{dir}^{insuff} = r_{dir}^{unavCZC} * r_{prod}^{Pdem}$$

In total, TIGER forecasts these risks 48 times each day, for each combination of border (2), direction (2), product (2) and 4h-block (6).

### 3.2.2. Example of the risk calculation for TIGER

This example examines a forecast for the import of aFRR+ from Austria by Czechia between 04:00 and 08:00, i.e. the border AT/CZ, the direction AT→CZ, the product aFRR+.

The Risk 1 value for the 100 MW scenario is assessed by the machine learning algorithm to be 60 % based on the exogenous data. For the 0 MW scenario, the risk is always set to 0%.

The share of instances in the last year, in which the available CZC is larger than or equal to 5 MW and lower than 100 MW, $r^{reduction}$ is 9,5 %. The risk reduction factor $r^{reduction}$ is thereby calculated to be 0,5 %. For each scenario decreasing from 100 MW, the risk reduction factor is subtracted to calculate the value for Risk 1.

With this, the Risk 1 value $r_{dir}^{unavCZC}$ for all scenarios would be as follows:

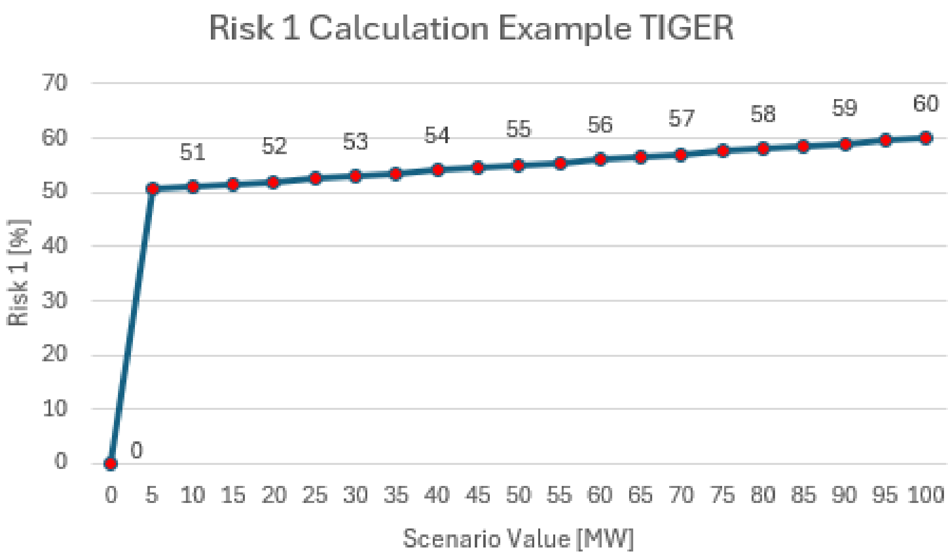


**Figure 1: Risk 1 Calculation Example TIGER**

Risk 2 $r_{prod}^{Pdem}$ is calculated for the same scenarios as Risk 1; however, for simplicity, only six of the scenarios are depicted. The cumulative distribution function showing the likelihood that a certain Balancing Energy demand in Czechia is depicted in blue. For each scenario, this curve is evaluated at the value indicating the domestically procured reserves, i.e. the reserves that can be activated reliably.

It is assumed that the country in question has a dimensioned balancing capacity demand of 200 MW. To identify the reserves that are certain to be procured domestically, the scenario value is subtracted from the demand of 200 MW. For the scenario of 20 MW, for example, the domestically procured capacity would be 180 MW, indicating a Risk 2 value of 8%.

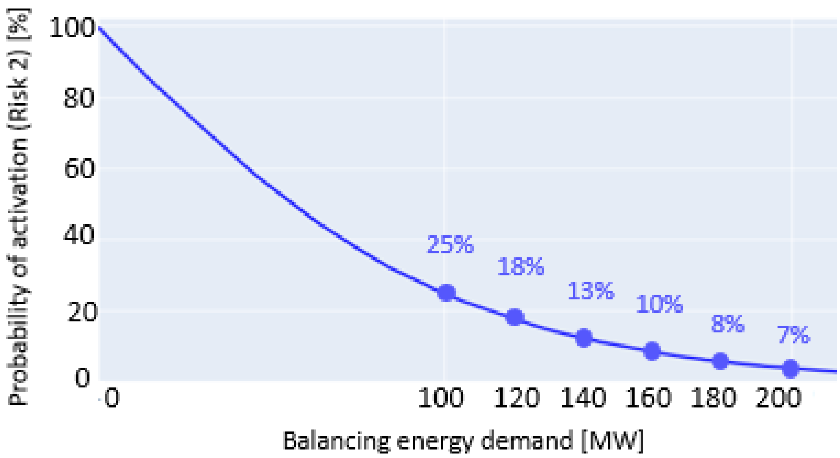


**Figure 2: Risk 2 Calculation Example TIGER**

Risk 3 $r_{dir}^{insuff}$ is calculated by multiplying Risk 1 and Risk 2. The results for this example are as follows (for simplicity, only six of the 21 scenarios are explicitly calculated):

| Scenario value [MW] | Risk 1 [%] | Risk 2 [%] | Risk 3 [%] |
|---|---|---|---|
| 0 | 0 | 7 | 0 |
| 20 | 52 | 8 | 4,16 |
| 40 | 54 | 10 | 5,4 |
| 60 | 56 | 13 | 7,28 |
| 80 | 58 | 18 | 10,44 |
| 100 | 60 | 25 | 15 |

**Figure 3: Risk 3 Calculation Example TIGER**

## 4. Initial Exchange Limit Determination

In the forecasting process, TIGER and FOX calculate the risk of unavailable CZC (Risk 1), and the risk that the necessary reserve capacity is not available (Risk 3) for each border, direction, product and 4h-block.

To translate these forecasted risks into IELs, each ALPACA TSO determines Acceptable Risk Levels (ARL) for Risk 1 (ARL 1) and Risk 3 (ARL 3). Risk 2 is not explicitly considered in the IEL determination. The ARLs for each border, direction, product and 4h-block are set by the importing TSO (see Figure 4).

| TSO | Validity Period | Border | Direction | Product |
|---|---|---|---|---|
| CEPS | Any | AT/CZ | AT→CZ | aFRR+ |
| | | | CZ → AT | aFRR- |
| | | CZ/DE | DE→CZ | aFRR+ |
| | | | CZ→DE | aFRR- |
| APG | | AT/CZ | CZ→AT | aFRR+ |
| | | | AT→CZ | aFRR- |
| DE TSOs | | CZ/DE | CZ→DE | aFRR+ |
| | | | DE→CZ | aFRR- |

**Figure 4: Overview of TSO Responsibility Defining Acceptable Risk Levels**

Every forecasted scenario is assessed on whether the forecasted risks are greater than the ARLs provided. If the respective ARL is greater than or equal to the forecasted risk, the scenario is accepted. Otherwise, it is rejected. The scenario with the highest capacity value, for which both Risk 1 and Risk 3 are accepted, is set as the IEL.

*Example:*
This example examines a forecast for the import of aFRR+ from Austria by Czechia (see chapter 3.2.2). For simplicity, only six of the 21 scenarios are evaluated.

The ARLs set by CEPS are 55% for ARL 1 and 5% for ARL 3. In this case, for the scenarios 0 MW and 20 MW, both Risks are accepted. For the scenario 40 MW, Risk 3 is rejected, and for 60 MW, 80 MW and 100 MW, all are rejected. The highest scenario, for which both risks are accepted, is 20 MW. This is the determined IEL.

| Scenario value [MW] | Risk 1 [%] | Risk 1 Evaluation | Risk 3 [%] | Risk 3 Evaluation |
|---|---|---|---|---|
| 0 | 0 | Accepted | 0 | Accepted |
| 20 | 52 | Accepted | 4,16 | Accepted |
| 40 | 54 | Accepted | 5,4 | Rejected |
| 60 | 56 | Rejected | 7,28 | Rejected |
| 80 | 58 | Rejected | 10,44 | Rejected |
| 100 | 60 | Rejected | 15 | Rejected |

**Figure 5: Example of Accepted and Rejected Scenarios**