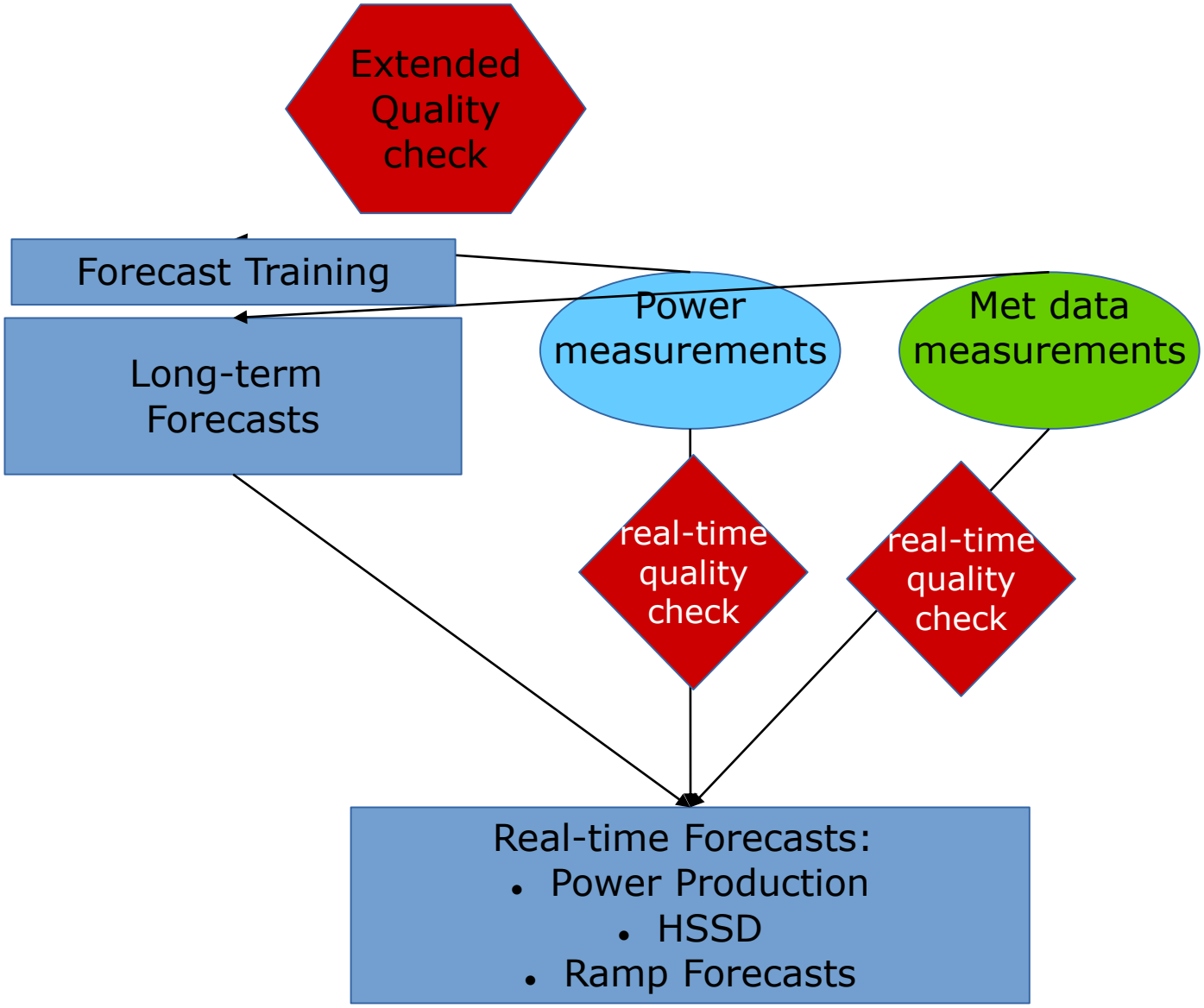
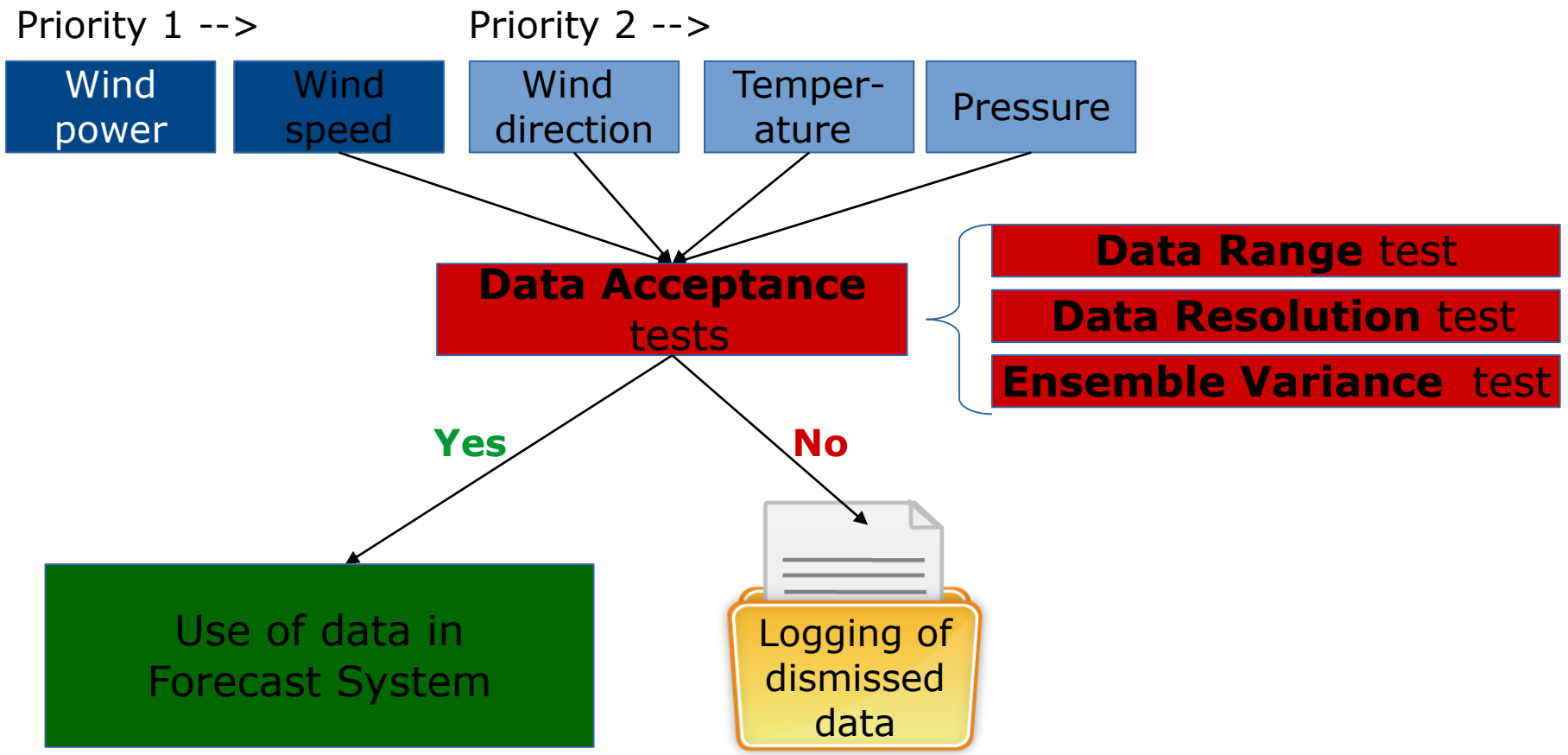
Use of Measurements in the Forecasting Process



Real-time Quality Check of Met Measurements



Extended Quality Check of Met Measurements

Priority 1 Priority 2 -->

Wind speed | Wind direction | Temper-ature | pressure

Range test

Resolution test

System Accuracy Statistical tests of forecasted versus measured values

Conversion model to generate power from met variables

System Accuracy of forecasted power (X) against active power (Y_1) and measured SCADA (Y_2)

	Maximum Bias	Maximum MAE	Minimum Correlation	Measurement Unit
Wind speed	3.00	3.00	0.65	m/s
Wind direction	13.00	20.0	0.55	deg
Air temperature	2.00	2.50	0.75	degC
Air pressure	50.00	85.0	0.90	mBar

Table 2: Meteorological data variable and their error threshold limit for statistical tests

MAE, CORR, BIAS, Ensemble variance

+ Delivery > 97.5% of time

+

	Unit	Range	System Accuracy	Measurement Resolution
Wind speed	m/s	0 - 70	≥ 5% improvement	0.1m/s
Wind direction	deg	0 - 360	Statistical and Variance test within acceptable limits as per Table 2	1.0 deg
Air temperature	deg C	-40 - 70		0.1 deg C
Air pressure	mBar	735 - 1060		1 mBar

Table 1: Meteorological data signal accuracy and resolution

Z = MAE(X)- MAE(Y)

Z ≥ 5%

Extended Quality Check of Met Measurements

The **validation methodology is a combination of various consistency checks**:

1) forecasted wind speed versus measured wind speed
2) forecasted temperature, wind direction, pressure against measured values
3) forecasted power versus active power checked with SCADA MW
4) Computed active power from measured wind speed versus actual active power
5) Comparison against previous years of the same wind farm
6) Comparison to the average error level for wind farms in the same period

Statistical tests and metrics for the System Accuracy Tests

The statistical test and metric used in the analysis is similar to the verification of the forecast error, **except that we use the forecast as the reference**, because it is the measurement that we need to validate due to it's uunknown accuracy level.

We use different statistical tests in order to have the best possible data basis for the interpretation of the data accuracy.

- **BIAS**:The BIAS in itself should be low, but is no guarantee of correctness of the data, because a BIAS can be low for the incorrect reason
- **MAE**:MAE and BIAS together show, if the data has an offset.
- **CORRELATION**:The correlation allows for easy detection of constant measurements as well as sign errors.
- **Ensemble Variance**: accounts for rapid local changes in the weather not present in the forecast. Ensemble variance sets a minimum requirement of data being inside a slightly extended ensemble spread

Priority 1: System Accuracy Tests for Wind Speed Data

Wind speed is the most critical variable for an accurate wind power forecast. A WFPS should deliver wind speed data signals that describe the wind farm power output (MW) with a certain accuracy excluding periods where there are dispatch signals or wind farm outages.
The Available Active Power (AAP) is a signal received by EirGrid from the wind farm and is defined in the Grid Code as 'The amount of Active Power that the Controllable WFPS could produce based on the current wind conditions. The Available Active Power shall only differ from the actual Active Power if the Controllable WFPS has been curtailed, constrained or is operating in a restrictive Frequency Response mode'. The AAP signal itself is subject to EirGrid quality standards2.
Hence the target is that the reported measured wind speed data signal from a WFPS shall be an improvement over the forecasted wind speed in predicting WFPS power output (MW) compared to the AAP of the WFPS.

The improvement will be calculated as follows:
☐ Predicted wind farm power output (MW) using forecasted wind speed (refer to this as F).
☐ Predicted wind farm power output (MW) using measured wind speed at the wind farm site (refer to this as M).
☐ Calculate the MAE of F compared to the AAP of the WFPS (refer to this as X).
☐ Calculate the MAE of M compared to the AAP of the WFPS (refer to this as Y).
☐ **X-Y=Z**

The required standard is **Z ≥ +5%**; the measured wind speed should be an improvement of at least 5% over the forecasted wind speed in predicting WFPS power output. A positive number will indicate an improvement of the predicted WFPS power output using measured wind speed over the forecasted wind speed. A negative number will indicate the measured wind speed was worse than the forecasted wind speed in predicting WFPS output.
The same methodology will be used to calculate wind power generation from forecast wind speed and measured wind speed. The data period will be the same taking account of missing data from both forecast and measured wind speed.

Priority 2: Procedure for statistcal System Accuracy: Bias, MAE and Correlation

The wind direction, air temperature and air pressure are less critical meteorological variables than wind speed. Measuring data signal accuracy for these variables is therefore adequate using a range around the forecast of the variable. The forecast is used as the reference as it has a known accuracy level. Statistical tests are used to provide the best possible data basis for the interpretation of the data accuracy. The statistical tests are:

- ☐ **Bias** – result of systematic error that either over or under estimates the true value. The bias number should be low.

- ☐ **Mean Absolute Error** – a measure of how close forecasts or predictions are to the eventual outcome. It is a measure of difference between two continuous variables, in this instance the forecast and measured meteorological data values.

- ☐ **Correlation** – is a measure of the strength and direction of the linear relationship between two variables i.e., in this instance the forecast and measured meteorological data values.
  The desired aim is to have Correlation + MAE + BIAS within acceptable threshold error limits (allowing for known forecast error) as detailed in Table 2: Meteorological data variable and their error threshold limit. The three tests together show a complete picture of the accuracy of the measured data compared to the forecast data.

Ensemble Based Variance

Another necessary test is ensemble based variance which is meteorological and statistical and will take into account rapid local changes in the weather not present in the forecast. Ensemble based variance sets a minimum requirement of data being inside the ensemble spread with a minimum band around the mean. The band width around the mean will update every hour depending on the weather at the WFPS; providing a wider band when required during rapid weather changes.

The advantage of the ensemble based variance test is that in a given month where there has been very uncertain weather with rapid changes the correlation test may fail but the variance test will succeed. In this scenario the meteorological data will be accepted within limits as the ensemble variance test is more intelligent. All statistical tests are required to give a complete overall picture of the quality of the meteorological data signal. For instance if the correlation for all WFPS is poor in a given month it was a month with a very challenging weather pattern. However, if only a small number of WFPS have poor correlation results then it is the quality of the meteorological data signal of these WFPS which is the cause.