EXPERT GROUP REPORT

ON

RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 1: FORECAST SOLUTION SELECTION PROCESS

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1 BACKGROUND AND OBJECTIVES

1.1 BEFORE YOU START READING

This is the first part of a series of three recommended practices that deal with the selection and design of renewable energy forecasting solutions in the power industry.

The first part "Forecast Solution Selection Process", which is the current document, deals with the selection and background information to be collected and evaluated when designing or renewing a forecasting solution for the power market.

The second part of the series "Benchmarks and Trials", of the series offers recommendation on how to best conduct benchmarks and trials in order to test ddifferent forecasting solutions against each other and the fit-for-purpose.

The third part "Forecast Evaluation", provides information and guidelines regarding effective evaluation of forecasts, forecast solutions and benchmarks and trials.

If you already have experience in setting up a forecast solution and you have an up-to-date IT infrastructure, then it is recommended to go straight to part 2 or 3.

The information in this recommended practices guideline will provide input to important considerations in this process, if you are considering e.g.

- renewal of your IT infrastructure
- require new forecasting products
- need to extend or reduce the amount of vendors engaged
- you are starting from scratch to build a forecasting solution

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An overview of the decision support tool to help develop structured processes in the design and planning for a new, or renewal of a, forecasting solution can be found in chapter 3, while chapters 1 and 2 provide background information and initial considerations.

It is recommended to use the table of contents actively to find the topics that are most relevant for you.

1.2 BACKGROUND

The forecast’s effectiveness in reducing the costs for the variability management of power generation from wind and solar farms is dependent upon both the accuracy of the forecasts and the ability to effectively use the forecast information in the grid management decision-making process. Therefore, there is considerable motivation for stakeholders acting in the power market to try to obtain high quality forecasts and effectively use this information as input to other operational processes or trading.

This document is intended to provide guidance to stakeholders who are seeking a forecasting solution that fits their purpose and enables them to work efficiently and economically responsible.

In recent years, carrying out trials or benchmarks seemed to be an industry practice in the power market with an easy and uncomplicated decision process for many. In reality, trials are often expensive for both the end-user and the vendor, are quite complicated, nor entirely conclusive. Benchmarks have little value for commercial vendors, except in their start-up phase, and end-users can often not count on results that reflect state of the art. Further, if trials and benchmark studies lead to a dissatisfying result, forecasting solutions become increasingly criticized for their value. And, providers that may have had the most technically qualified solution at hand, but did not score best at a specific (maybe simplified) test, may be deselected.

This recommended practices document will therefore focus on the key elements to consider when seeking to establish or renew a forecasting solution that fits one’s purpose.

In summary, this document provides recommendations and a decision support tool to establish procedures for an effective selection process.

1.3 OBJECTIVES

This document is intended to serve as guidance and best practice for private industry, academics and government for the process of obtaining an optimal wind or solar power forecast solution for their applications and, in particular, it provides guidance to the design and requirements for effective renewable energy forecasting solutions.

These guidelines and best practices are based on years of industry experience and intended to achieve maximum benefit and efficiency for all parties involved.

1.4 DEFINITIONS

In the discussion of the process of obtaining the best possible forecasting solution, there are a number of terms and concepts that are used. Several of the key terms and concepts are defined in the following.
Note, these definitions are kept as general as possible with a focus on forecasting processes in the power industry and may not have such a completely general character to be applied to other areas of business.

Request for Information (RFI)*: a RFI allows the client to get information about the state-of-the-art business practices and available commercial products in the preparation or design of a forecast application or solution for a specific target process. By providing information about the target application, a client can ask vendors for their recommendations and experience to solve specific tasks. Such information is useful in the preparation and design of a new system, but also for systems that need to be rebuilt due to changing requirements.*

Request for Proposal (RFP): a RFP is a tender process, where the client prepares a document laying out the requirements of a forecasting solution and asking vendors to propose a solution and price quote. Usually, a set of minimum requirements are provided that become part of a contractual agreement for the awarded vendor.

Renewable Energy Forecast Benchmark: an exercise conducted to test features and quality of a renewable energy forecast such as wind or solar power.

The exercise is normally conducted by an institution or their agent and usually includes multiple participants from private industry forecast providers or applied research academics.

Renewable Energy Forecast Trial: an exercise conducted to test the features and quality of a renewable energy forecast such as wind or solar power. This may include one or more participants and is normally conducted by a private company for commercial purposes. A trial is a subset of a Renewable Energy Forecast Benchmark.

2 INITIAL CONSIDERATIONS

This part of the IEA Wind Task 36 recommended practice series provides guidelines for those whose task is to provide a plan and justification for a forecasting solution selection process. It intends to assist in finding the necessary information when navigating through the vast jungle of information, opinions and possibilities and ensures that crucial details are being considered.

2.1 TACKLING THE TASK OF ENGAGING A FORECASTER FOR THE FIRST TIME

The most important considerations and first question to answer, when starting out to plan the selection of a forecasting solution is to be clear about the desired outcome. A lot of time and resources can get wasted for all involved parties on trials and benchmarks that are not aligned with requirements, also when planned and conducted by personnel with little or no experience in the subject.

To avoid this, the recommended practice is to carry out a market analysis in the form of a “request for information” (RFI) and to establish a requirement list (see also APPENDIX B).

In some cases, it can be beneficial to test vendors or solutions prior to implementation. The difficulty with this method lies in the evaluation of trials, especially, when they are of short duration. In many cases they do not answer the questions an end-user needs answered, because such tests mostly are simplified in comparison to the real-time application and, but still require significant resources. For such cases, this guideline provides other methods for an evaluation of different forecast solutions/vendors.

The pitfalls and challenges with trials and/or benchmarks are the topic of part 2 of this series of recommended practices. Table 1 summarizes some of the aspects and help the decision process as to where and when trials or benchmarks may not be the best choice when selecting a forecast solution. The column “recommendation” in Table provides other methodologies that may be used to evaluate a forecast solution. Additionally, a typical set of questions to be asked to service providers will be provided in APPENDIX A.

Table 1: Recommendations for initial considerations prior to forecast solution selection for typical end-user scenarios

Scenario	**Limitation**	**Recommendation**
Finding best service provider for a large portfolio (> 1000MW) distributed over a large area	Test of entire portfolio is expensive for client and service provider in terms of time and resources. Simplifying test limits reliability of result for entire portfolio.	RFI and RFP, where service provider's methods are evaluated and incentive scheme on the contract terms provides more security on performance.
Medium sized Portfolio (500MW< X < 1000MW) over limited area	Test of entire portfolio is expensive for client and service provider in terms of time and resources. Simplifying tests limits reliability of result for entire portfolio.	RFP, where service provider's methods are evaluated. Building of a system that enables change of service provider and incentive scheme may be more efficient than a test in the long run. (More detail on incentive schemes are found in section 3.9.3.3 and Part 3 of this guideline).
Finding best service provider for small sized portfolio (< 500MW)	Test of portfolio requires significant staff resources, a budget and a minimum of 6 months. Difficult to achieve significance on target variable in comparison to required costs and expenses – trial costs makes solution more expensive.	Test is possible, but expensive. Cheaper to setup an incentive scheme and a system, where the suppliers may be exchanged relatively easily.
Micro portfolio (< 100MW) or single plants	Cost of a trial with many parties can easily be higher than the cost of 1 year of forecasting. Time for a trial can delay real-time experience by up to 1 year.	Evaluation of methodologies and setting up the internal system with an incentive scheme and ease of service provider exchange is more beneficial. (More detail on incentive schemes are found in section 3.9.3.3 and Part 3 of this guideline)

Scenario	**Limitation**	**Recommendation**
Sale of generation at power market	Best score difficult to define, as sale is dependent on market conditions and a statistical score like RMSE or MAE cannot reflect the best marketing strategy, considering the uncertainty of a forecast and the associated costs	Strategic choice of forecast provider and incentive scheme better than real-time test. Strategic choice may be: choice of vendor in comparison to others that use different, uncorrelated weather forecasts, uncorrelated weather-to-power model, unique forecast methodology, flexibility, expandable, etc. Incentive scheme ensures resources and incentive for continuous performance improve-ments (see section 3.9.3.3, Part 3).
Market share of service provider is high	Monopolies in the power market mean that forecast errors are correlated among generators. This could lead to increased balancing costs. The forecast error might be low, but the costs for errors may be disproportionately high.	Ask about the market share of a provider and do not choose one with a share > 30% as the only provider!
System operation in extreme events	Today, extreme (or rare) events are better fore-casted,when considering weather uncertainty. Statistical approaches relying solely on historic information may not be sufficient. A PoE50 (probability of exceedance of 50%) needs to have equally high probability in every time step above and below.	The IEA Task 36 WP 3 has been dealing with uncertainty forecasting and provides recommendations for such situations. See section . Forecasting solution needs to be weather and time dependent, i.e. only physical methodologies (ensemble forecast systems) fulfill such tasks
Critical Ramp forecasts	Critical ramp forecasts are part of an extreme event analysis and require probabilistic methods with time dependency	Consider difference between a ramp forecast and a critical ramp as extreme event analysis that requires time + space dependent prob. methods such as ensemble forecasts. See references for uncertainty forecasts.

Scenario	Limitation	Recommendation
Blind forecasting, i.e. no measurement data available for the park or portfolio	Only useful for portfolios, where small errors are canceled out and indicative regarding performance. Without measurements, forecast accuracy will be non-representative of what accuracy can be achieved by training forecasts with historical data. Evaluation can only be carried out for day-ahead or long-term forecasts, if measurements are collected throughout the trial.	If you have a portfolio > 500MW, a blind test against a running contract can provide an inexpensive way to test the potential of a new provider. For single sites, the benefits of training are so large (>50% of error reduction at times) that blind forecasting is not recommended. It wastes resources for everybody without providing useful results.
Dynamic reserve	Deterministic forecasts cannot solve reserve requirements.	It is necessary to apply probabilistic methods for reserve calculation for intermittent resources such as wind and solar. See section .

2.1.1 Purpose and Requirements of a Forecasting Solution

Once the limitations are defined, the next step is to define what objectives the project has. As outlined in Table 1, it poses very different forecasting strategies to the project, if the objective is e.g. system balance of renewables or selling generated electricity at the power market.

When designing a forecast solution the first task is to consider extremes and estimate risks; mean error scores are not that important. Large errors are most significant, as they could potentially lead to lack of available balancing power. The second consideration is to look at the uncertainty of the forecast and make sure to choose a forecast that is uncorrelated to others. The mean error of a forecast is important, but not a priority target, if the objective e.g. is to use a forecast that generates low balancing costs. This is not always the same, because errors that lie within the forecast uncertainty are random.

Such errors can only be reduced by strategic evaluations and decisions, not by methodology. If the objective is to calculate dynamic reserve requirements, probabilistic forecasts are required and should be part of the requirement list. When choosing a forecast solution, understanding the underlying requirements is key to the selection the most suitable solution.

It is not enough to ask the vendors for a specific forecast type without specifying the target objective. For this reason, defining the objective is most important. And, if there is no knowledge in the buyer'as organization regarding the techniques required to reach the objective, it is recommended to start with a RFI (see section 1.4) from different forecast providers and thereby gain an understanding and overview of the various existing solution and their capabilities.

2.2 INFORMATION TABLE FOR SPECIFIC TASKS AND TARGETS

Table 2 lists a number of targets and points to the chapter or part of this guideline series, where the topic is described in detail. The table provides some typical targets and where to find information on how to achieve the best solution for that target.

Table 2: Information table of specific targets

Target	Information
How to find the best forecast solution	Section 3
Creating a requirements list	Section 3.3.1, 2.1.1, 3.2.1, and 3.2.2
Deterministic versus Probabilistic	Section 3.2.1 and 3.9.1
Decision support tool and practical guide to forecasting	Figure 1
Evaluation of vendors: interviewing or conducting trial?	Section 3.9 and References in section
Do I need to test reliability and consistency?	Section 3.2.1 and 3.9.3.1
How do I know which forecast solution fits my purpose best ?	Section 2.2 and 3.9.4, APPENDIX A
How do I build up sufficient IT infrastructure for a trial?	Part 2: Trial Execution
Which metrics for what purpose?	Part 3: Evaluation of forecasts
Step-by-step guide for trials and benchmarks	Part 2: Trial Execution

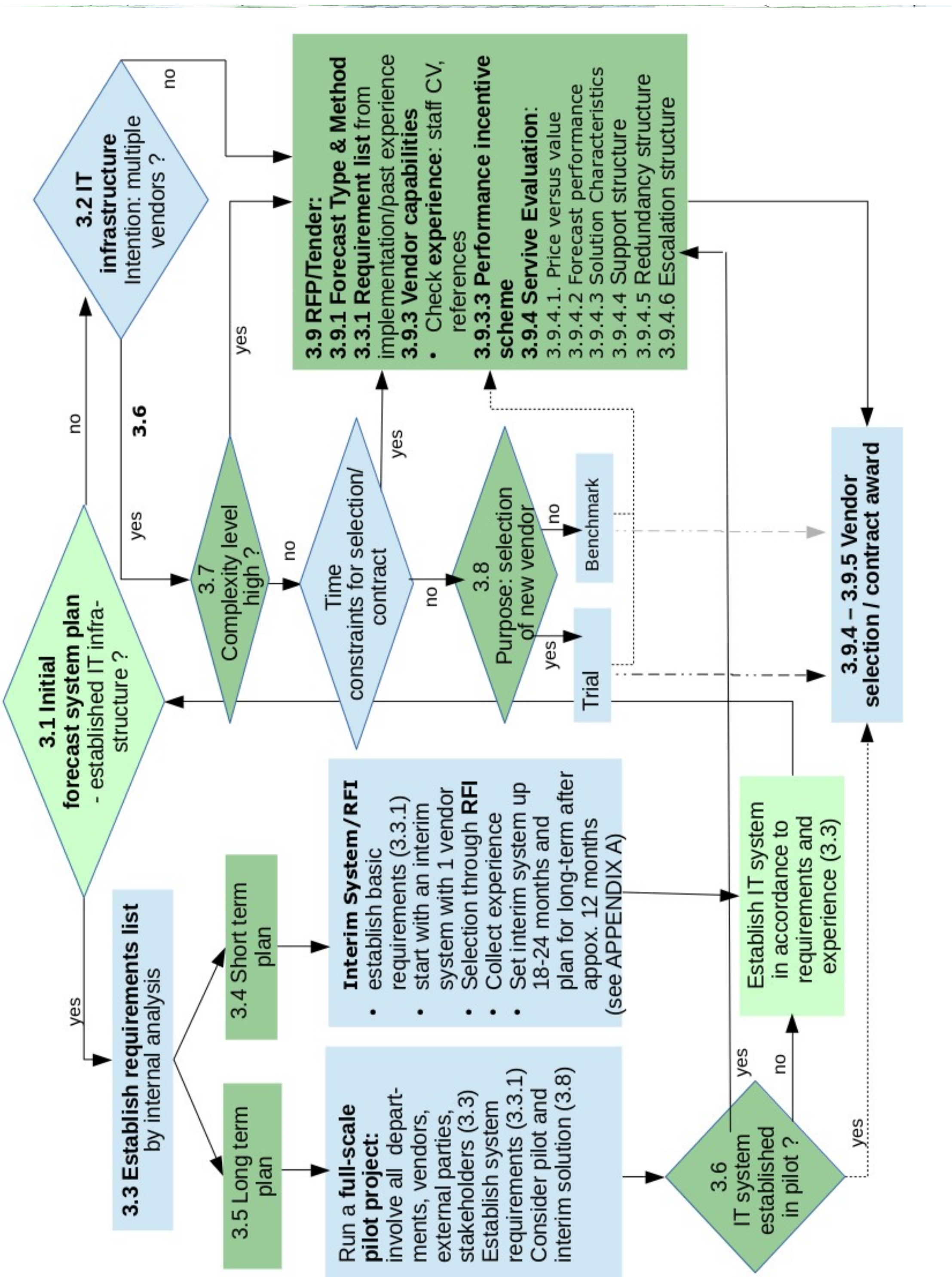
3 DECISION SUPPORT TOOL

From a forecast end-user perspective, it is a non-trivial task to decide which path to follow when implementing a forecasting solution for a specific application. Whether this is at a system operator, energy management company, a power producer or power trader, there are always multiple stakeholders involved in the decision-making process. A relatively straightforward way to decide for one path or another is to use a decision support tool. Figure 1 shows a decision support tool aimed at high- level decisions by managers and non-technical staff when establishing a business case for a forecasting solution. The high-level thought construct shown in Figure 1 is targeted to assist in considering the required resources and involvement of departments and staff for the decision process. The decision tool is constructed to begin with initial considerations to establish a "Forecast System Plan". The tool aims to assist in taking a decision on the major dependencies to the planned item. There are cross references in the decision tool and referrals to different decision streams, dependent on the answer at each step of the decision flow.

Starting at the very top, the first major dependency when planning a new, or renewal of a, forecasting system is the IT infrastructure. Dependent on the status of IT infrastructure, the recommended procedure splits up here and follows in different paths. This is not to be understood that the IT infrastructure has higher priority over the forecasting solution itself. It is rather to sharpen the awareness that if the IT infrastructure is not in place yet or needs renewal for a new technology to be implemented, the IT needs to be part of the decision process from the very beginning.

The decision support tool in Figure 1 provides a high-level overview of the process for finding the most suitable forecast solution and vendor,. The following sections provide guidance in how to use the decision support tool. There are detailed descriptions and explanation for the more detailed planning and design of the decision process.

<u>Notice for the practical usage</u>: To find the detailed recommendations, the numbering ofthe boxes in Figure 1 correspond to the headlines in the following sections.



3.1 Initial forecast system plan - established IT infra-structure ?
3.2 IT infrastructure Intention: multiple vendors ?
3.3 Establish requirements list by internal analysis
3.4 Short term plan
3.5 Long term plan
Interim System/RFI
• establish basic requirements (3.3.1)
• start with an interim system with 1 vendor
• Selection through RFI
• Collect experience
• Set interim system up 18-24 months and plan for long-term after appox. 12 months (see APPENDIX A)
Run a full-scale pilot project:
• involve all depart-ments, vendors, external parties, stakeholders (3.3)
• Establish system requirements (3.3.1)
• Consider pilot and interim solution (3.8)
3.6 IT system established in pilot ?
Establish IT system in accordance to requirements and experience (3.3)
3.7 Complexity level high ?
Time constraints for selection/ contract
3.8 Purpose: selection of new vendor
Trial
Benchmark
3.9 RFP/Tender:
3.9.1 Forecast Type & Method
3.3.1 Requirement list from implementation/past experience
3.9.3 Vendor capabilities
• Check experience: staff CV, references
3.9.3.3 Performance incentive scheme
3.9.4 Servive Evaluation:
3.9.4.1. Price versus value
3.9.4.2 Forecast performance
3.9.4.3 Solution Characteristics
3.9.4.4 Support structure
3.9.4.5 Redundancy structure
3.9.4.6 Escalation structure
3.9.4 – 3.9.5 Vendor selection / contract award
3.6
yes
no

3.1 INITIAL FORECAST SYSTEM PLANNING

The planning of a forecasting system for wind and solar power is a complex task and highly individual. This guideline therefore focuses solely on aspects that are of general planning and management tasks specific to the implementation of wind power or solar power production forecasts into an operational environment.

Note that any information and considerations about forecast technologies or methodologies here has the sole objective to provide guidelines on the impacts of commonly implemented technologies for decision processes, not a recommendation for or against any technology.

There is strong focus on the IT infrastructure as one of the most crucial tasks in the implementation and integration of forecast solutions that are prone to become limiting factors for changes at later stages. For that reason, it is recommended that the IT infrastructure is established or, if already available, evaluated together with the planning of the forecast solution and methodology. Especially the IT solution's ability to develop along with changes in forecast practices, possible statutory changes among others are important aspects to consider. Databases are another aspect to consider, as they are prone to have limitations that prevent changes to incorporate more information or store information in a different way. Such consideration need to take place and should be part of the decision process and the requirement list (see section 3.3).

3.2 IT INFRASTRUCTURE CONSIDERATIONS

The starting point of the tool is the IT infrastructure. If a company has already built an appropriate infrastructure, finding a forecasting solution or a vendor for a specific forecasting solution is less complicated. The reason for this is that in this case, the forecast provider will need to conform to file formats, communication protocols or security constraints, for example. If an IT infrastructure for the forecasting solution is to be established or renewed it needs to be closely following the technical requirements of the solution.

If no IT infrastructure has been built yet, an internal analysis of the needs are required. In this analysis, it is important to know, whether there is a short-term goal with an objective to be reached with time constraints, or whether it is a long-term plan that needs to be satisfied.

The important aspects in the IT infrastructure to be considered are:

- database structure
- communication layer
- monitoring and error handling
- data storage and historic data accessibility

In general a forecast system interface, whether in-house or outsourced requires multiple data streams, starting from measured power and weather variables. Usually, there is a connection to the power unit's SCADA (Supervisory control and data acquisition) system. However, the measurement data needs storage and a data flow of measurements and other production data from the power plants to the forecaster needs to be added as one more of the various internal data flow processes.

It needs to be decided whether there is a need to access other external data sources, such as NWP data, or the forecast data itself.

Dependent on the setup of the forecasting solution, it is also necessary to evaluate how fast accessible historic data has to be, for example to carry out internal analysis, external data delivery to vendors, etc.

3.2.1 IT impacts for single versus multiple forecast vendors

Impacts on multiple vendor solution:

- infrastructure more complex
- database requirements are higher due to higher data volumes
- Strategy required for forecast: mixing versus primary/secondary forecast

IT infrastructure impacts for single vendor solution:

- reliability requirement of solution high
- monitoring requirement higher for up-time
- higher requirements for quality control of forecasts
- less data volume than for multiple-vendor solutions
- database structure less complex than for multiple-vendor solutions

3.2.2 IT requirements for deterministic versus probabilistic forecasts

From an IT infrastructure and architectural perspective, deterministic and probabilistic forecasting solutions are quite different. The database requirements are by a factor of 10 to 100 higher for the latter. Dependent on the way the probabilistic forecasts are used, they add significant amounts to the storage requirements.

Nevertheless, storage and computational resources are changing with changing requirements in industry and hence should not per se be considered a barrier or limitation for the integration or implementation of new technologies. But, they need consideration and careful planning.

The advantages and disadvantages of the deterministic versus the probabilistic solution from a IT perspective are similar to single versus multiple providers in section 3.2.1.

3.3 ESTABLISHMENT OF REQUIREMENT LIST

Establishing a requirement list for a forecasting solution is highly individual and depends on many factors, such as internal requirements and external offerings. Every end-user will have very specific needs to fulfill. There are however common areas that require consideration. This is how the recommendation list in 3.3.1 has to be interpreted.

Two of the fundamental aspects when establishing a requirements list are:

1. Description of the current situation

> In this process, it is imperative to describe exactly all processes, where forecasting is required and how these processes are interlinked. Here it is essential to get the different departments involved, also the IT department. The more accurate you can describe the situation at hand, (e.g. integration plans, use of forecasts, market situation, statutory aspects, IT restrictions, limitations and methods for data exchange exist, current or future challenges, etc.), the more straight forward it will be to (1) ask questions to the forecasting vendors regarding forecasting methodology, but also (2) get clarity of the involved processes enabling forecasting, (3) provision of liabilities and guarantees.

2. Engage forecast vendors, stakeholders and independent consultants

Questions to vendors should be of technical character regarding forecast methodology, but also on available data exchange methodologies, required input data for the models and system support.

If you already have a forecast vendor, it is recommended to engage with the forecaster to discuss the current situation and where the forecaster sees limitations and potential for improvements. Often, forecast providers need to adopt their forecasts to a specific need and even though a new technology may be available, it is not used due to current limitations.

Other vendors, stakeholders and independent consultants may at any stage be engaged, not only when it comes to establishing a new, or renewal of, a forecasting system. For new systems, it is recommended to engage different forecast vendors and stakeholders to provide insight from a variety of experiences.

In all cases, it is essential to describe the planned objective and name limitations, if they are already known. The more information that can be shared the better a vendor, stakeholder or consultant can evaluate what is considered the most appropriate solution.

APPENDIX A contains an additional listing of recommended considerations that are applicable also for RFI's.

3. Description of the envisaged Situation

The description of the envisaged situation is most important for the implementation of a solution. Analysis of the current situation, the forecast vendor(s) input and other organizational and statutory requirements should lay the basis for an envisaged new system. It is recommended to put as much detail into this part as possible. The following requirement list assists in defining all aspects for the planning phase of a forecasting system.

Recommendation in short: Describe (1) the current situation, (2) engage vendors and stakeholders and (3) describe the envisaged situation in great detail. Ask specific questions that are required to get the highest possible level of detail for the decision process.

3.3.1 Requirement List

The following areas are recommended to be considered in the list:

IT infrastructure

- communication/data exchange with the forecast vendor(s)
- communication/data exchange with the asset operation (wind/solar parks)
- database and storage implications
- accessibility of data/information of internal users
- application interfaces to internal tools (e.g. graphics, models, verification, metering)
- information security policies

Forecast Methodology and Attributes

- Weather input
- Methodology of weather to power model
- Application/model background for each forecast product
- Forecast time horizons
- Forecast frequency
- Forecast uncertainty

Support and Service

- service level for each product (e.g. 24/7, business hours etc.)
- system recovery
- failure notifications and reporting
- escalation procedures
- service documentation
- contact list for different services
- staff training

Contracting

- contract length
- amendment possibilities
- additional work outside contract
- licenses
- confidentiality (NDA)
- insurances
- sub-contracting
- Price table for each product category

Performance and Incentivization

- Verification methods
- Verification parameter
- definition of payment structure (boolean or sliding areas)
- Expected accuracy for each forecast horizon

3.4 SHORT-TERM SOLUTION

In the case of a short-term solution, current requirements should be listed and analyzed in accordance with possible time limitations. It is recommended that a short-term solution is sought, if the countriy's current policy does not seem to be stable to make long-term investments, or a here-and-now issue needs to be solved and experience gained. In such cases, a relatively simple methodology that can be implemented fast and easy is the best way forward.

Today, this can be found by carrying out a RFI, where vendors can suggest how to best and easiest fulfill very specific needs. Due to IT constraints in many organizations, such solutions sometimes are set up with delivery by Email. This is not a recommended practice for security and reliability reasons, but can help to fill a gap between a long-term solution and an urgent need.

Despite the shortcomings, interim solutions are recommended as they are valuable in respect to experience with forecasting data and it's handling inside the organization. If such solutions are employed while a long-term plan is being developed, it can be of great benefit for the long-term solution. Such solutions should last approx. 18-24 months. Planning for a long-term solution should ideally start after 12 months.

Staying with an interim solution can bare disadvantages for the forecast user, if it has real limitations on security (e.g. email delivery) and reliability, as such limitations may not be problematic for a long time, but reliance on non-redundant systems can cause sudden uncontrollable situations arising from missing forecasts of wind and solar power generation.

For this reason, we posted the question about the IT system (see also Figure 1) at the end of the short-term solution, as this is a crucial part in the next step. We recommend that this is taken as a priority topic, once practical experience with forecasting has been gained.

3.5 LONG-TERM SOLUTION

Developing a long-term solution can be cumbersome and difficult, as many aspects have to be considered, from policies to governmental plans or corporate strategies.

A practical way forward is to conduct a full-scale pilot project, where different solutions are tested and verified over a period of at least 1 year. The advantage of such a pilot project is that there is the possibility to verify and evaluate different solutions and their fit for purpose over a longer time span.

Moreover, a pilot project is characterized by:

- Involvement of all relevant departments (internal and external parties/stakeholders)
- Establish system requirements
- Pilot maybe used as interim solution

The disadvantage is that it takes a long time and hence is costly and it is not given that there is a very clear winning solution to a specific area or task. On the other hand, to find the most appropriate long-term solution needs many considerations, not only technically, but also economically and whether a solution is future compatible, i.e. capable of solving growing capacities and requirements expected to become part of the solution at a later stage. So, the experience of the vendor in adjusting, maintaining and developing a solution with changing needs may be a challenge for some and the business philosophy for others. Such vendor policies can be identified and clarified when carrying out long-term tests. The box therefore feeds into the question about an appropriate IT system. If this has not been established, it is recommended to prioritize the IT before going further.

The end of a pilot project has therefore 3 further paths:

(1) vendor selection
(2) redefining requirements to start a solution bottom up
(3) carrying out a RFP with the identified requirements.

3.6 GOING FORWARD WITH AN ESTABLISHED IT SYSTEM

In the case an IT system has been established and new vendors or a renewal of the system is the objective for the project, there are various possibilities to move forward.

Crucial in this phase is again to set target and objectives. If the target is to find out, whether there exist forecast vendors on the market that may provide forecasts with other methods or for a lower price, it may be a good way forward to carry out a trial or benchmark.

Dependent on the structure of the system, or complexity of the system and time constraints, a benchmark/trial or a RFP as alternative are recommended. One crucial criterion when deciding on the two alternatives RFP or trial/benchmark in existing IT environments is whether the IT structure can handle multiple suppliers.

If this is not the case, any evaluation against an existing supplier can be cumbersome and at times impossible. The recommended practices guideline part 2 is going into detail with the topic of evaluations being::

- **representative** (including consistency)
- **significant** (including repeatable)
- **relevant** (including fair and transparent)

These are the key points when carrying out a comparison.

3.7 COMPLEXITY LEVEL OF THE EXISTING IT SOLUTION

Apart from accuracy or statistical skills of forecasts, there are also other aspects to be considered when choosing a forecast supplier. It has been observed that such evaluations based on non-technical skills or skills leading to forecast performance for a specific purpose have been underestimated in their importance. One of these aspects is the ability to improve, which is fully excluded with a trial/benchmark as sole decision-making criterion (besides price) as capability of vendors. It is often forgotten that long-term experience in a specific area can provide significant advantages. And, verifying only a small part of a complex system for practical reasons may result in misleading results (see 3.6 “representative”, “significant” and “relevant”).

Complex systems are seldom easy to simulate in trials and will always disqualify some participants, when it comes to the selection process. To conclude, the complexity of a system and the purpose of a forecast within a complex corporate structure are significant aspects to consider in a forecast solution selection.

Recommendation: The path to follow in case of complex structures and requirements are best performed by a RFP process, where core capabilities should be evaluated, when choosing a forecasting solution.

3.8 SELECTION OF A NEW VENDOR VERSUS BENCHMARKING EXISTING VENDOR

If there are no time constraints and the complexity level of the running system is not too high, or a new system is in the process of being built, a trial or a benchmark exercise can be very useful.

Recommendation: Conduct a trial in case a new vendor has to be selected and a trial can be carried out in such a way that the results are fair, transparent, representative and significant. Carry out a benchmark, if the purpose is not from the outset to engage a new vendor, but also to compare the capabilities of a vendor with other vendors or against newer technology. In both cases the invited vendors need to be notified of the purpose of the exercise.

3.9 RFP EVALUATION CRITERIA FOR A FORECAST SOLUTION

If complexity levels are high and if time constraints do not allow for a lengthy trial or benchmark, the RFP should be compiled with care in order to fulfill all requirements and yet not ask for more than needed.

The most important evaluation criteria for a forecast solution to be defined in a RFP is:

- the type of forecast that is required (e.g., hours-, day-, or week-ahead)
- the methodology that is applied to generate these forecasts
- compliance to requirements

It is recommended that this first step should be vendor independent. And, if this cannot be defined, it is recommended to first conduct an RFI to scan the industry on their capabilities and their recommendation which type and methodology should be applied for the specific needs. APPENDIX B contains typical questions for an RFI.

Only when the forecast type and methodology is defined, the vendor comes into play. The important factors to consider here are:

- capabilities (experience)
- support and maintenance services

The sections below describe these considerations in detail.

3.9.1 Forecast Type and Methodology

Most users will agree that they want to obtain forecasts with the best possible forecast accuracy for their application. A benchmark or a trial has in the past often been viewed as a way to determine which provider is most likely to deliver the best possible forecast performance. In theory, this is a reasonable objective. In practice, it is not recommended to rely solely on a test.

The following subsections will address a number of key issues associated with the dilemma of finding the best forecasting solution with a simple and non-costly exercise for both the end-user and the forecast provider.

3.9.1.1 Forecast solution Type

Single versus multiple forecast providers

It has been widely documented (e.g. Nielsen et al., 2007, Sanchez, 2008) that a composite of two or more independent state-of-the-art forecasts will often achieve better performance (accuracy) than any of the individual members of the composite over a statistically meaningful period of time. Indeed, many of the FSPs internally develop their approach and services on that basis. And, there are well founded reasons for an end-user to consider the use of multiple FSPs to achieve better forecast accuracy. However, in a practical sense, there are several advantages and disadvantages that should be considered. When building up a solution, it is recommended to consider the following aspects:

Benefits of using multiple vendors

(1) There are a number of FSPs in today's forecast market that exhibit performance that is close to the state-of-the-art. It may be advantageous for reliability to assemble a set of state-of-the-art forecasts, unless they are highly correlated.

(2) Higher forecast accuracy can often be achieved by blending forecasts from multiple uncorrelated[1] FSPs.

Drawbacks of using multiple vendors

The benefits of having multiple vendors also contain inherent challenges for the end-user:

(1) Increased internal costs, even if two “cheap” vendors may be less costly than one high-end forecast vendor, employing multiple vendors increases internal costs significantly due to increased amounts of data and IT processes.

(2) Blending algorithms need to be intelligent. Multiple forecasts can be beneficial, but only if the algorithm is intelligent to only blend/mix in case of all forecasts being available and easy to retrain when forecast statistics change. With two forecast vendors this is relatively easy. If there are more than two, it becomes more complex.

(3) Forecast improvements are difficult to achieve with a multi-forecast provider solution. When improvements are achieved on the vendor side, the blending algorithm is becoming inconsistent and can result in worse scores than before, unless long-term historic data can be delivered. In other words, the handling and the improvement of forecasts are complex and difficult with multiple forecasts.

(4) Multi-vendor Solutions cannot be incentivized as easily to achieve continuous performance increase over time. Although incentive schemes can be a good way to provide resources to the FSP for continuous improvements, in a multi-vendor environment, this can be counter productive, as changing statistical characteristics of forecasts can have a bad influence on the resulting blended forecast. Any end-user needs to be aware of this pitfall, when choosing a solution and take mitigating measures.

1 Uncorrelated forecasts here means ideally that both the underlying weather information and weather to power conversion model is not the same. At least one part must be different, where the weather input has more weight.

(5) Multiple points of failure - with multiple forecast providers, the IT infrastructure needs to contain more logic to deal with one or more data streams when there are, for example, delivery disruptions, timeliness, or quality issues.

3.9.1.2 Deterministic versus Probabilistic

Many forecasting tasks need a discrete answer. For that reason forecasting solutions have been mostly fed with deterministic forecasts in the past. Although weather forecasts and hence also power forecasts of intermittent resources such as wind and solar power, contain inherent uncertainties, probabilistic forecast products have been associated with forecasts not being discrete. The probability of an generic power generation at time x cannot be used in a trading application with the purpose to bid into the market.

As penetration of variable generation resources increase and digitialization increases, the uncertainty information for decision taking can and is being processed by algorithms, also those whose output needs a discrete answer. Deterministic forecasts by default suppress the underlying uncertainty in the forecasts. By using probabilistic forecasts this uncertainty can be taken into consideration in the decision processes.

The most common products of uncertainty or probabilistic forecasts are the probability of exceedance (PoE) values, typically given as PoE05, PoE50 and Poe95, quantiles, or percentiles or confidence bands (see Glossary for definitions).

The advantage of probabilistic/uncertainty forecasts in comparison to the deterministic “best guesses” is the possibility to act upon the probability of an event to occur, rather than being surprised, when the deterministic forecast is wrong. In power markets, for example, a probability of exceedance of 50% (PoE50) is an important parameter for a system operator, as such forecasts prevent the market to be able to speculate against system imbalance. Extreme ramping, high-speed shut-down risk, unit commitment and dynamic reserve allocation are other examples, where probabilistic forecasts are beneficial or required. In other words, wherever there are some kind of uncertainty and extreme to be considered that may have impact on a decision or the costs of a process, probabilistic forecasts provide the necessary information to an end-user to take a decision upon some objective uncertainty criteria.

Recommendation: When establishing or renewing a forecasting system, the question should not be posed on advantages and disadvantages for deterministic or probabilistic forecast solution, but rather whether a deterministic solution can fulfill the objective of the application.

Information about probabilistic methodologies can be found in the References Material under "Uncertainty Forecast Information", especially in a review on probabilistic methods for the power industry (Bessa et al. (2017)) .

3.9.2 Forecast horizons

The forecast horizons play a major role in the ability to plan using forecasts. Today, there are 5 types of forecast horizons applied in the power industry:

1. Minute-ahead forecasts or nowcasts (0-120min)
2. Hours-ahead forecasts (0-12 hours)
3. Day-ahead forecasts (0-48 hours)
4. Week-ahead forecasts (48-180 hours)
5. Seasonal forecasts (monthly or yearly)

The **Minute-ahead forecasts** are in literature also sometimes referred to as *ultra-short term forecasts or nowcasts* and are mainly used in areas with high penetration and high complexity in system operation or significant risk for high-speed shut down and extreme events. These forecasts are either based on a statistical extrapolation of measurements or weather input together with measurements generated on minute basis.

The recommended practice depends on the severity and costs of the target value. For situational awareness, a simple extrapolation of measurements may be sufficient. For extreme events (e.g. ramps, high-speed shut down) the involvement of weather related forecasts in high time resolution is recommended.

Hours-ahead forecasts, or sometimes referred to as s*hort-term forecasts,* correct a day-ahead forecast by using real-time measurements and extrapolate from local real-time observations an improved view of the current state and the next few hours.

There are different methods available from simple extrapolation of measurements to advanced weather and distance- dependent algorithms. It's recommended to get details of a short-term forecast methodology described by the vendors, as quality and usability can differ strongly with availability of data, quality of measurement data etc.

If the target is e.g. ramp forecasting, system control, a very large fleet or quality issues with measurement data not dealt with by the end-user, simple algorithms are often not capable of providing a sustainable picture of the next few hours.

The **Day-ahead forecasts** are widely-used forecasts for general system operation, trading and short-term planning. Traditionally, they are based on a combination of weather models and statistical models.

The **Week-ahead forecasts,** *sometimes referred to as long-term forecasts,* are usually applied in cases where the focus is not on forecast accuracy, but on forecast skill, e.g. in situations, where trends prevail over granularity. These forecasts are most valuable as a blending of a number of different forecasts or from an ensemble predication system, where the small-scale variability is reduced. If this is done, such forecasts can serve to reduce reserve costs and generate more dynamic reserve allocation as well as auctions.

The **Seasonal forecasts** *sometimes referred to as ultra-long-term forecasts,* predict variations due to seasonal and or climate variability. They may be derived based on climatology, correlation to various climate indices and oscillatory phenomena, climate models, or a combination of these methods. Ensemble methodologies are the most preferable method due to the inherent uncertainty on such time frames. The most simple method is to analyze past measurements.

Recommendation: Key when choosing a methodology is to carefully analyze the accuracy requirements of the task to solve. For trading of futures in a trading environment a simple methodology may be sufficient. Tasks such as grid balancing, grid infrastructure planning or long-term capacity planning however require more advanced methodologies. It is recommended to choose the method according to the need to capture quantities only (simple method) or capture also climatic extremes (advanced method).

3.9.3 Vendor Capabilities

3.9.3.1 Experience and Reliability

Experience is a key element of a successful vendor and implementation of the forecasting solution. It can usually be evaluated by the selected references that are provided and measured by conducting interviews with customers of similar type or by asking for information about the vendor's background and experience with similar customers. If a vendor is new to the market that may not be possible. In this case, staff resources and experience of the key staff is usually indicating, whether the experience level for the minimum requirements is given.

Reliability is also connected to experience, as it implies the reliable implementation and real-time operation of a forecasting service. It is an important aspect and may be derived by requiring examples of similar projects and interviewing references. It can also save a lot of work and resources in comparison to carrying out a trial, if reliability and experience with respect to e.g. complex IT infrastructure, security aspects, reliable delivery and provision of support etc. are a more crucial aspect than specific statistical performance scores.

Recommendation: Ask vendors to describe their experience and provide references and CV of key staff members.

3.9.3.2 Ability to maintain state-of-the-art performance

The previous section provided an overview of all of the considerations for the technical aspects of forecast type and methodology.

In order to assure that the forecast vendor can maintain state-of-the-art performance it is recommended to verify, whether the provider engages in ongoing method refinement/development and forecast improvement activities.

Recommendation: Evaluate by asking the vendor to provide information about

- research areas and engagement

- references to staff publications of e.g. their methodology, project reports
- references of participation in conferences/workshops
- percent of revenue reinvested into research and development

3.9.3.3 Performance incentive Schemes

A performance incentive scheme is the most effective way to ensure that a forecaster has an incentive to improve forecasts over time and also allocates resources to it. By setting up a performance incentive scheme, the client acknowledges that development requires resources and vendors have not only an economic incentive to allocate resources for further developments, but can also influence their reputation. Incentive schemes do not have to be enormously high, but usually range between 10-30% of the yearly contract sum.

Establishing a performance scheme

What must be key to a performance incentive scheme is that it reflects the importance of the forecast parameters that are incentivized for the client!

The evaluation of such forecast parameters should be selected according to:

1. the objective of the forecasting solution
2. the use/application of the forecasts
3. the available input at forecast generation time

The **objective (1)** in this context is defined as the purpose of the forecast. For example, if a forecast is used for system balance, an evaluation should contain a number of statistical metrics and ensure that there is an understanding of the error sources that the forecaster can improve on. A typical pitfall is to measure performance only with one standard metric, rather than a framework of metrics reflecting the cost or loss of a forecast solution. For example, if a mean absolute error (MAE) is chosen to evaluate the performance in system balance, an asymmetry in price for forecast errors will not be taken into account. Also, if e.g. large errors pose exponentially increasing costs, an average metric is unsuitable.

The use or **application of forecasts (2)** is defined in the context of where forecasts are used in the organization and where these have impact and influence on internal

performance metrics or economic measures. For example, a wind power forecast that a trader uses for trading the generation of a wind farm on a power market has two components: revenue and imbalance costs.
The revenue is defined by the market price for each time interval, whereas the cost is defined by the error of the forecast, the individual decision that may have been added to the forecast and the system balance price. When evaluating a forecast in it's application context, it is important to choose an evaluation that incentivizes the vendor to tune the forecast to the application. A forecast that is optimized to avoid large errors may create lower revenue. However, if income is evaluated rather than revenue, such a forecast may be superior due to lower imbalance costs. On the other hand, if the end-user makes changes to the forecast along the process chain, the forecast evaluation must stop, where it is outside the forecast vendor's influence.

The available input at **forecast generation time (3)** is most important when evaluating short-term forecasts that use real-time measurements. For example, if the forecast is evaluated against a persistence forecast with corrected measurements rather than with the measurements that were available at the time of forecast generation, the evaluation is to the disadvantage of the forecaster. The same applies, if aspects that affect the forecast such as curtailments, dispatch instructions, turbine availability, are not taken out of the evaluation or are corrected.

Recommendation: When incentivizing a forecast solution with a performance incentive, the evaluation need to consider the non-technical constraints in the forecast and the parts that a forecaster does not have influence upon. A fair performance incentive scheme needs to measures the performance of a forecast by blacklisting any measurement data that is incorrect or corrupt, that contains curtailments, dispatch instructions, reduced availability or other reductions outside of the forecasters influence. Evaluation against persistence forecasts also need to be done with the available data at the time of forecast generation to not give advantage to persistence.
Additionally, single standard statistical metric (e.g. MAE or RMSE) alone cannot be recommended.

More details on the purpose and interconnection of statistical metrics for evaluation of incentive schemes can be found in part 3 of this recommended practice and in the references under “Evaluation and Metrics”.

Structure of a performance incentive payment

The structure of performance incentive scheme is an individual process and contractual matter between parties.

When establishing the structure of a performance incentive it is recommended to consider that by choosing a maximum and minimum, the maximum value provides budget security to the end-user, also when e.g. changing from a very simple solution to an advanced one with much higher performance. The latter provides security to the forecaster to ensure that the basic costs for generation of forecasts are covered. Adding a sliding structure in between ensures the forecaster always has an incentive to improve, also when it is foreseeable that the maximum may not be achievable.

Recommendation: it is recommended to apply a maximum incentive payment and a maximum penalty or minimum incentive. A sliding change is preferable over for a boolean (yes|no) decision for incentive payments, as it always encourages forecast improvement efforts.

3.9.4 Evaluation of services

The recommended practice in any evaluation is to consider a number of factors that contribute to the value that a user will obtain from a forecast service. It is not possible to provide a complete list of factors to consider.

However, the most important factors that should be addressed are the following elements:

- Price versus value and quality
- Forecast Performance
- Solution Characteristics
- Speed of delivery
- Support structure

- Redundancy structure

The issues associated with each of these aspects will be addressed in the following subsections in more detail.

3.9.4.1 Price versus Value and Quality

The value of a forecast may or may not be directly measurable. In most cases however, the value can be defined for example in terms of cost savings or obligations and in that way provide an indication of the expected value from a certain solution.

Prices are difficult to evaluate. A low price often indicates that not all requirements may be fulfilled in operation or not all contractual items are accepted and left to the negotiations. For these reasons, care has to be taken in the evaluation process.

Some services and methods are more expensive than others on e.g. computational efforts, required licenses, database requirements, reliability, etc. Unless prices are driven by competition in a overheated market, a service price is normally coupled to the requirements and acceptance of contractual items. Some items such as reliability, customer support or system recovery can have high prices, but can always be negotiated to a different level. In an RFP end-users need to be aware of the relation between cost, value and associated service level to prevent vendors from speculation on negotiable item in the requirement list.

Recommendation: Following a decade of experience in the forecasting industry, the recommended practice on price evaluation is to connect technical and contractual aspects to the price and consider to let vendors detail contractual aspects that may be associate with high service costs separately, especially, if a fixed cost price is requested.
An example could be the requirement of full system recovery within 2 hours in a 24/7/365 environment. If there is no penalty associated, a vendor may ignore this requirement, which may result in a much lower price.
Requesting transparent pricing eases evaluation and makes sure that speculations regarding negotiable aspects of a service can be clearly compared.

3.9.4.2 Forecast Performance

Forecast performance evaluation should contain a number of metrics that are representative for the need to the forecast user. It is recommended to establish an evaluation framework for the performance evaluation. How to establish such a framework is dealt with in Part 3 of this recommended practice guideline.

3.9.4.3 Solution Characteristics

The solution characteristics of a forecast service also contains much value for an end-user and should get attention in the evaluation. It can be defined in terms of the available graphical tools, ease of IT services for retrieving data or exchanging data in real-time as well as historical data, customer support setup and staff resources connected to the forecasting solution.

This can be key for the operational staff to accept and be comfortable with a forecast service as well as having confidence in the service. Additional work that may be connected, but outside the scope of the operational service can also be key elements for a well functioning service.

Recommendation: Ask the vendor to describe how the system will be built up, how communication and support is envisaged and let them provide examples of graphics (if applicable).

3.9.4.4 Support Structure

Customer service is often under-estimated and in most cases second to an accuracy metric when selecting a vendor. Support can be a costly oversight if, for example, costs are related to a continuously running system or extreme events, where the user needs an effective warning system and related customer service. Support can have a relatively large cost in a service contract and may provide a false impression on service prices, if, for example support is only offered at business hours.

Recommendation: Definition of the required support structure should be part of the requirement list for any forecasting solution. For real-time forecasting solutions end-user need to ensure that there is an appropriate support structure in place. Considerations of the real-time environment, own resources and which of the forecasting business practices are of significance to the user should be carried out. Especially, where processes are supposed to run every day in the year.

Key elements for the customer support is:

- the responsiveness of the provider, when issues arise
- live support in critical situations

A support structure and it's management for operational processes additionally need to bind the following strategic areas together:

(a) Customer Support
(b) Operations Software and Service
(c) IT Infrastructure

The customer support (a) should be handled by a support platform, ideally with different forms for contact, e.g. telephone hotline and email ticket system.

Any end-user needs to ensure that third-party software used in the operational environment (b) is licensed and renewed and maintained according to the licensing party's recommendations.

The IT infrastructure (c) should ideally be ISO 9001 and ISO 27001 certified in cases, where real-time operation and security is of paramount importance.

3.9.4.5 Redundancy Structure

Redundancy depends very much on the end-users needs to maintain a frictionless and continuous operation. Forecasting is mostly carried out in real-time, which has an inherit requirement of being functional all the time. While there are many processes and targets for forecasting that may not require large redundancy and permanent up-time, the following recommendation is targeted to those end-users where forecasting is to some extend mission critical.

There are a number of different redundancy levels that need consideration and that can be achieved in various ways:

(1) Physical delivery of the service via IT infrastructure
(2) Content of the delivery via Forecasting methods

The delivery of the service (1) is connected to the IT infrastructure. Redundancy measures may be a combination of any of these:

- ➔ Delivery from multiple locations to mitigate connectivity failures
- ➔ Delivery from multiple hardware/servers to mitigate individual server failure
- ➔ Delivery with redundant firewalls to mitigate hardware failure
- ➔ Delivery through a ISP using Email, etc.

The redundancy of the forecast content is equally important as the physical delivery of the data, but often neglected.
It is recommended to consider any combination of the following redundancy measures for correct forecast content:

- ➔ redundant providers of weather input
- ➔ redundant/multiple providers of forecast service
- ➔ redundant input and mitigation strategy for weather models
- ➔ redundant input and mitigation strategy to power conversion models

Recommendation: Define the required redundancy level according to the importance of a permanent functioning service and the impact of delivery failure to other internal critical processes.

3.9.4.6 Escalation Structure

It is recommended for high-level contracts, where forecasting is critical to the end-users processes to get information about escalation structures in case of failure. This is especially important when employing only one forecast provider.

Recommendation: An end-user needs to have a description about structure and corresponding responsibilities for their operations staff in order to incorporate such information into own escalation structures in case of emergencies.

Table 4: Recommendation of a three tier escalation structure.

Escalation Level	Forecast service providers coordination	End-user side coordination
Level 1: failure to deliver service	Technical Staff	Operations Staff Project manager
Level 2: failure to recover or implement service	Project manager	Project manager Department manager
Level 3: failure to solve failure/recovery	General management	General management

Each level of escalation ideally contains the following structured process:

- Formulation of the problem/failure
- Root cause analysis
- Coordination of action plan for troubleshooting inclusive responsibilities
- Coordinated action plan progression
- Escalation to the next level or closure of escalation procedure

4 FINAL AND CONCLUDING REMARKS

While every forecasting solution for wind and/or solar power generation contains very individual processes and practices, there are a number of areas that all forecasting solutions have in common. For any industry it is important to establish standards and standardized practices in order to streamline processes, but also ensure security of supply with a healthy competition structure.

This document is providing state of the art practices that have been carefully collected by experts in the area and reviewed by professionals and experts in an appropriate number of countries with significant experience in wind energy forecasting. The recommendations are to encourage both end-users and forecast service providers to bring focus to areas of practice that are common to all solutions. The document will be updated as the industry moves towards new technologies and processes.

The key element of this recommended practice is to provide basic elements of decision support and thereby encourage end-users to analyze their own situation and use this analysis to design and request a forecasting solution for wind and/or solar power generation that fits their own purpose rather than applying a “doing what everybody else is doing”-strategy.

This document is also intended to serve forecast service providers new to the market or those wanting to evolve to a new level of service and support as a guideline to state of the art practices that should be incorporated into business practices.

References Material

NOTE: Access to references at IEA Wind Task 36 webpage: http://www.ieawindforecasting.dk

Forecast solutions, Trials and Benchmarks

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Glossary and Abbreviations

Ensemble Forecasting	Ensemble forecasts are sets of different forecast scenarios, which provide an objective way of evaluating the range of possibilities and probabilities in a (weather or weather related) forecast
Probabilistic Forecast	General description of defining the uncertainty of a forecast with objective methods. These can be ensemble forecasts, probability of exceedance forecasts, or other forms of measures of uncertainty derived by statistical models.
Quantile	A quantile is the value below which the observations/forecasts fall with a certain probability when divided into equal-sized, adjacent, subgroups.
Quartile	quantiles that divide the distribution into four equal parts.
Percentile	Percentiles are quantiles where this probability is given as a percentage (0-100) rather than a number between 0 and 1
Decile	quantiles that divide a distribution into 10 equal parts.
Median	the 2nd quantile, 50th percentile or 5th decile, i.e. the value, where the distribution has equally many values above and below that value.

Abbreviations

FSP	*Forecast service provider*
NWP	*Numerical Weather Prediction*
EPS	*Ensemble Prediction System*
NDA	*Non-disclosure Agreement*
RFI	*Request for Information*
RFP	*Request for Proposals*
TSO	*Transmission system operators*
ISO	*Independent system operator*

APPENDIX A: Clarification questions for forecast solution

In order to define the objectives and possible solutions for a forecasting system, it is recommended to follow an overall structure:

1. Describe your situation

In this process, it is imperative to describe exactly those processes, where you need forecasting in the future. Here it is essential to get the different departments involved, especially the IT department. The more accurate you can describe the situation you need to solve with forecasting (e.g. which IT restrictions, limitations and methods for data exchange exist, current or future challenges, etc.), the more straight forward it will be to (1) ask questions to the vendors regarding forecasting methodology, but also (2) get clarity of the involved processes enabling forecasting.

2. Ask Questions to the vendors

The questions to the vendors should be of technical character regarding forecast methodology, but also on available data exchange methodologies, required input data for the models and system support.

TYPICAL QUESTIONS FOR PART 1

Processes: Which processes require forecasting

Data:

- How will the data flow internally be solved: data storage, data exchange, data availability ?
- Which data do we collect that may assist the forecaster to improve accuracy

Data Formats:

- Which formats are required for applications, data exchange and storage ?

Applications:

- Who/which department will use the forecasts, are new applications required to make use of the forecasts ?

Education:

- Is it required to train staff in how to use forecasts ?

Policies:

- Are there policies, political or legal restrictions to be aware of when exchanging data with a forecaster ?

TYPICAL QUESTIONS FOR PART 2

The following are typical questions to get some overview of what is state-of-the-art in forecasting for renewables and what products are available on the market for a specific purpose.

- Describe the methodology you will use when generating forecast for (wind|solar|…)
- How many years of experience do you have in this specific area or related areas
- Required data fields for the forecasting model for the trial
- Time scales and IT requirements for the data for the forecasting model
- Required data for vendor's model, if adopted and used “live”
- Applicable charges for a trial with vendor
- Vendor’s forecast model forecast horizons

APPENDIX B: TYPICAL RFI QUESTIONS PRIOR TO OR IN AN RFP

Methodology

- What unique services can you provide that may address our needs ?
- What input weather data is used
- What methodology is used for power generation for the long-term (>1 days ahead) and short-term forecasting (0...24h).
- Can uncertainty forecasts or probability bands be provided ?[2] If yes, which methodology is being used.
- What are the minimum requirements for wind farm site data?
- Can a Graphical User Interface be provided to visualise forecasts ? If yes, please describe it in detail (e.g. platform dependence, user management, in-house installation or web-based).

Service Level

- What kind of service level does the provider offer (ticket system, personal support, call center, online support, etc.)
- What kind of service level is recommended for the specific service.
- Does the provider have outage recovery guarantee

Contract and Pricing

- What are restrictions and preferences on the pricing structure of your service (e.g. price per park, per MW, per parameter, per time increment)?
- What restrictions/preferences does the provider have in responding to RFPs ?

Experience

- Can the vendor provide minimum of 3 examples of your work that is applicable to our needs (e.g. forecast accuracy, references, methodology)?
- Does the company have significant market shares in the market/area of business
- Additionally, can your company supply products or information that you consider relevant for us when setting out an RFP ?

[2] For a review on methodologies see reference material in section