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18th Wind Integration Workshop
International Workshop on Large-Scale Integration of Wind Power into Power Systems as well as on Transmission Networks for Offshore Wind Power Plants
16 - 18 Oct 2019
Dublin, Ireland

Lessons Learned from the IEA Task 36 OpenSpace Workshop

Session 7C: Forecasting II

Presented by

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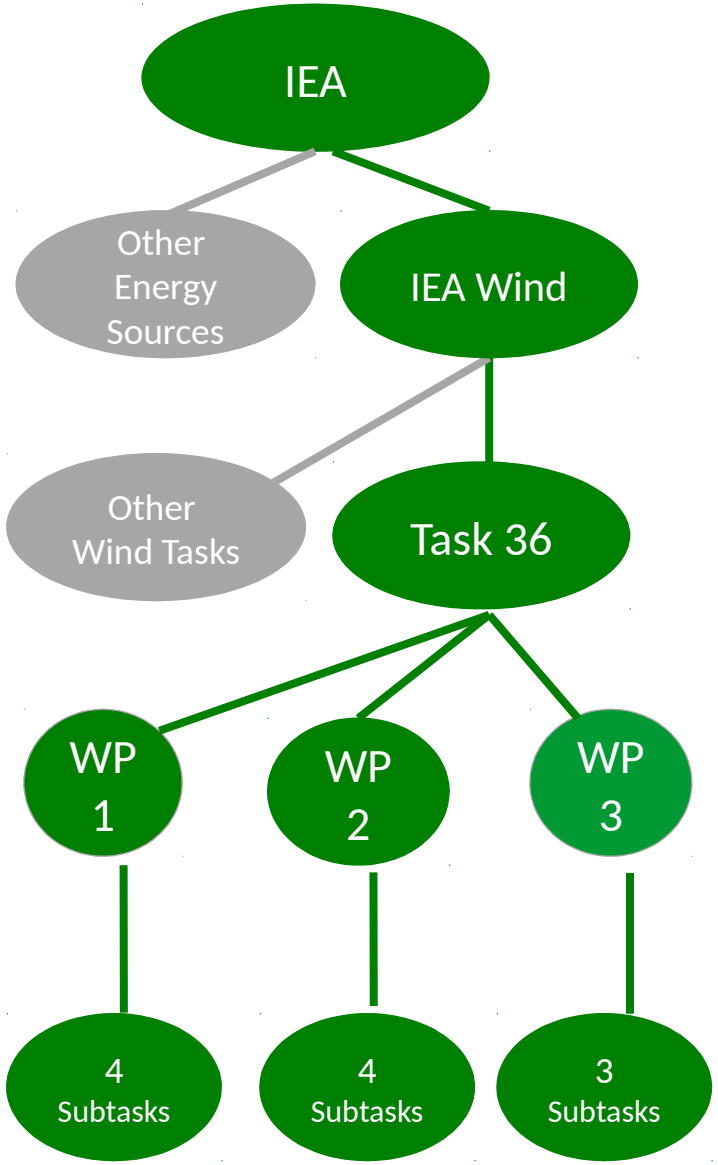
Overview of Presentation

1. Background: IEA Task 36 – Wind Forecasting
2. Overview of IEA Best Practices for Forecasting Solution Selection
3. Overview of Yesterday’s OpenSpace Workshop

IEA Task 36 - Forecasting for Wind Energy



What is the IEA (International Energy Agency)? (www.iea.org)

- International organization within OECD with 30 members countries and 8 associates
- Promotes global dialogue on energy, providing authoritative analysis through a wide range of publications
- **One activity: convenes panels of experts to address specific topics/issues**

Task 36: Forecasting for Wind Energy: (www.ieawindforecasting.dk)

- One of 17 Tasks of IEA Wind: https://community.ieawind.org/home
- Phase 1: 2016-2018; Phase 2: 2019-2021
- Operating Agent: Gregor Giebel of DTU Wind Energy
- Objective: facilitate international collaboration to **improve wind energy forecasts**
- Participants: (1) research organization and projects, (2) forecast providers, (3) policy-makers and (4) end-users & stakeholders

Task 36 Scope: Three "Work Packages"

- WP1: Global Coordination in Forecast Model Improvement
- WP2: Benchmarking, Predictability and Model Uncertainty
- WP3: Optimal Use of Forecasting Solutions

Task homepage: http://www.ieawindforecasting.dk/

Task 36 Phase 2: Work Package Scope

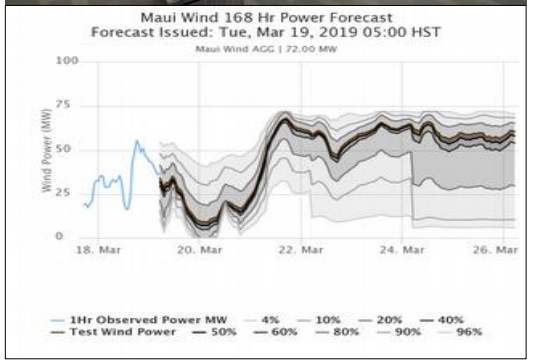
- **WP 1: Global Coordination in Forecast Model Improvement**
  - 1.1 Compile list of available wind data sets suitable for model evaluation
  - 1.2 Annually document field measurement programs & availability of data
  - 1.3 Verify and validate NWP improvements with common data sets
  - 1.4 Work with the NWP centers to include energy forecast metrics in evaluation of model upgrades
- **WP 2: Benchmarking, Predictability and Model Uncertainty**
  - 2.1 Update the IEA Recommended Practice on Forecast Solution Selection
  - 2.2 Uncover uncertainty origins & development through the whole modelling chain
  - 2.3 Set-up and disseminate benchmark test cases and data sets
  - 2.4 Collaborate with IEC on standardisation for forecast vendor-user interaction
- **WP 3: Optimal Use of Forecasting Solutions**
  - 3.1 Use of forecast uncertainties in the business practices
  - 3.2 Review existing/propose new best practices to quantify value of probabilistic forecasts.
  - 3.3 Develop data requirements for real-time forecasting models for use in grid codes

WP2: The Problem and an Approach for a Solution

- **Documented Benefits:** Use of forecasts to manage the variability of renewable power generation can lower integration costs while maintaining high system reliability

- **Problem:** A substantial amount of the potential value of forecasting is not realized due to the use of non-optimal forecast solutions by users

- **Potential Mitigation:** International group of experts interacts under the framework of IEA Wind Task 36 to formulate “best practices”, educate and disemminate state of the art information on forecasting



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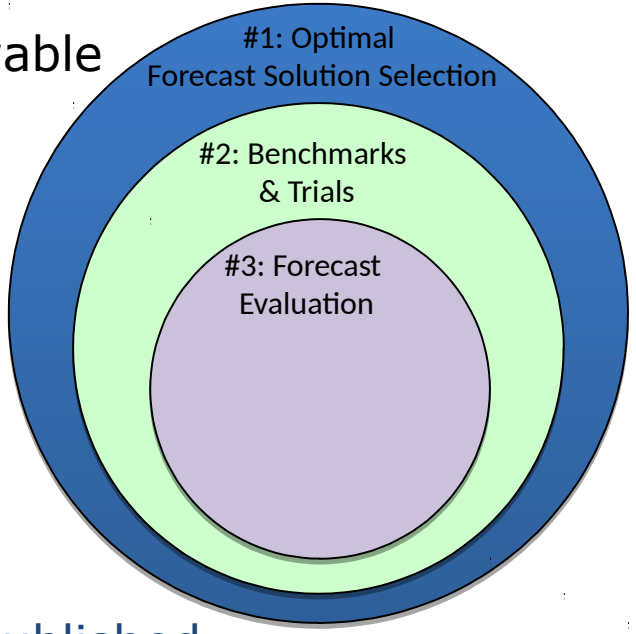
Overview of IEA-WIND RECOMMENDED PRACTICE for the Implementation of Wind Power Forecasting Solutions (Task 2.1)

Task lead: Corinna Mohrlen, WEPROG

Target: Compile guidance for the implementation of renewable energy forecasting into system operation



Approach: Develop a set of 3 documents that specify IEA Wind Recommended Practices for:

1. **Selection of an Optimal Forecast Solution**
2. **Design and Execution of Benchmarks and Trials**
3. **Evaluation of Forecasts and Forecast Solutions**

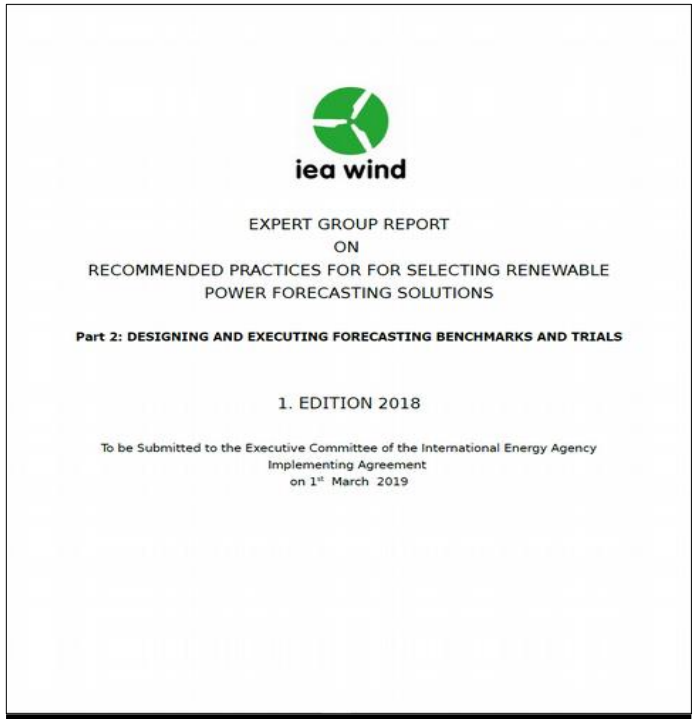
Current Status: Version 1 accepted by IEA Wind ExCo & published

The best practices guidelines are based on many years of industry experience and are intended to achieve maximum benefit for all parties involved in the forecasting area.

Recommended Practice page: http://www.ieawindforecasting.dk/Publications/RecommendedPractice

IEA Best Practice Recommendations for the Selection of a Wind Forecasting Solution: Set of 3 Documents

- Part 1: Selection of an Optimal Forecast Solution



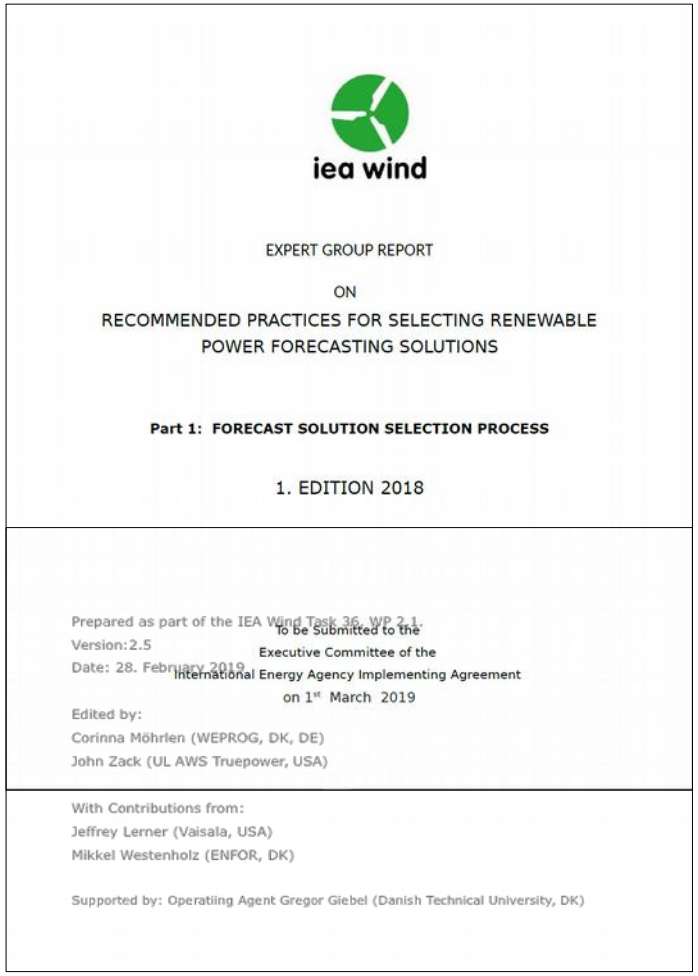
- Part 2: **Design and Execution of Benchmarks and Trials**

- Part 3: Evaluation of Forecasts and Forecast Solutions

Approved version available since September 2019 on the Task 36 web site:
http://www.ieawindforecasting.dk/Publications/RecommendedPractice

Part 1: Selection of an Optimal Forecast Solution

- Presents an overview of the factors that should be considered in the solution selection process
- Discusses the issues associated with each selection factor
- Provides a “decision support tool” to assist users in the design and execution of a solution selection process
- Provides practical lists and FAQ’s for the RFI/RFP tendering process



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EXPERT GROUP REPORT

ON

RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 1: FORECAST SOLUTION SELECTION PROCESS

1. EDITION 2018

Prepared as part of the IEA Wind Task 36, WP 2.1.
Version: 2.5
Date: 28. February 2019

To be Submitted to the
Executive Committee of the
International Energy Agency Implementing Agreement
on 1st March 2019

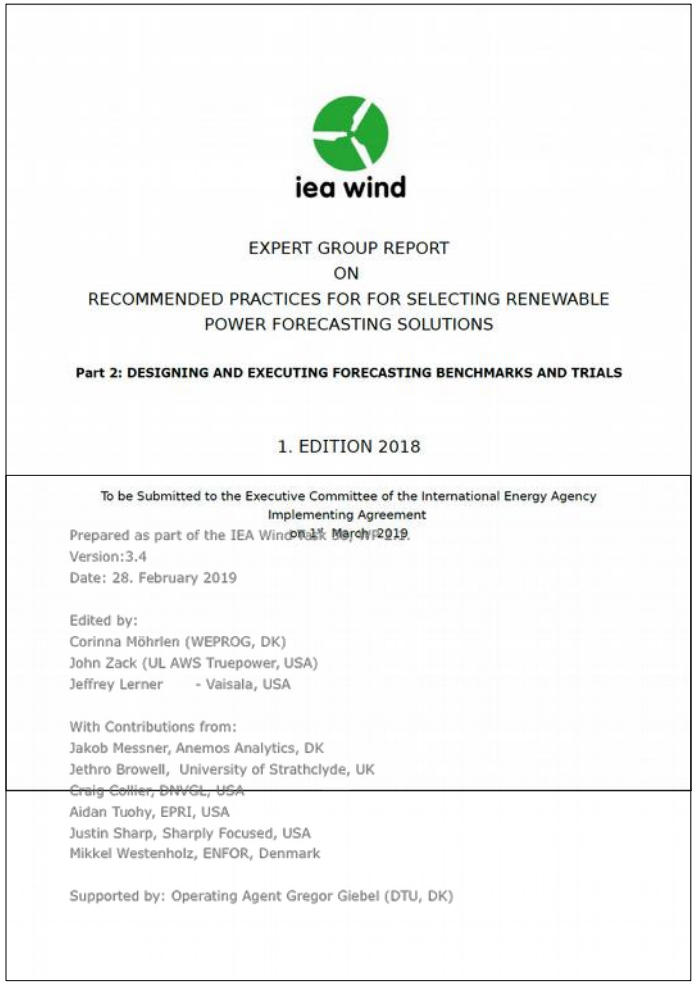
Edited by:
Corinna Möhrlen (WEPROG, DK, DE)
John Zack (UL AWS Truepower, USA)

With Contributions from:
Jeffrey Lerner (Vaisala, USA)
Mikkel Westenholz (ENFOR, DK)

Supported by: Operating Agent Gregor Giebel (Danish Technical University, DK)

Part 2: Conducting a Benchmark or Trial

- Presents the three phases of a forecasting benchmark or trial
- Discusses the factors and issues that should be considered in each phase
- Provides a list of pitfalls to avoid



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EXPERT GROUP REPORT
ON
RECOMMENDED PRACTICES FOR FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 2: DESIGNING AND EXECUTING FORECASTING BENCHMARKS AND TRIALS

1. EDITION 2018

To be Submitted to the Executive Committee of the International Energy Agency Implementing Agreement on 1st March 2019

Prepared as part of the IEA Wind Task 36, Y1-2018
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Edited by:
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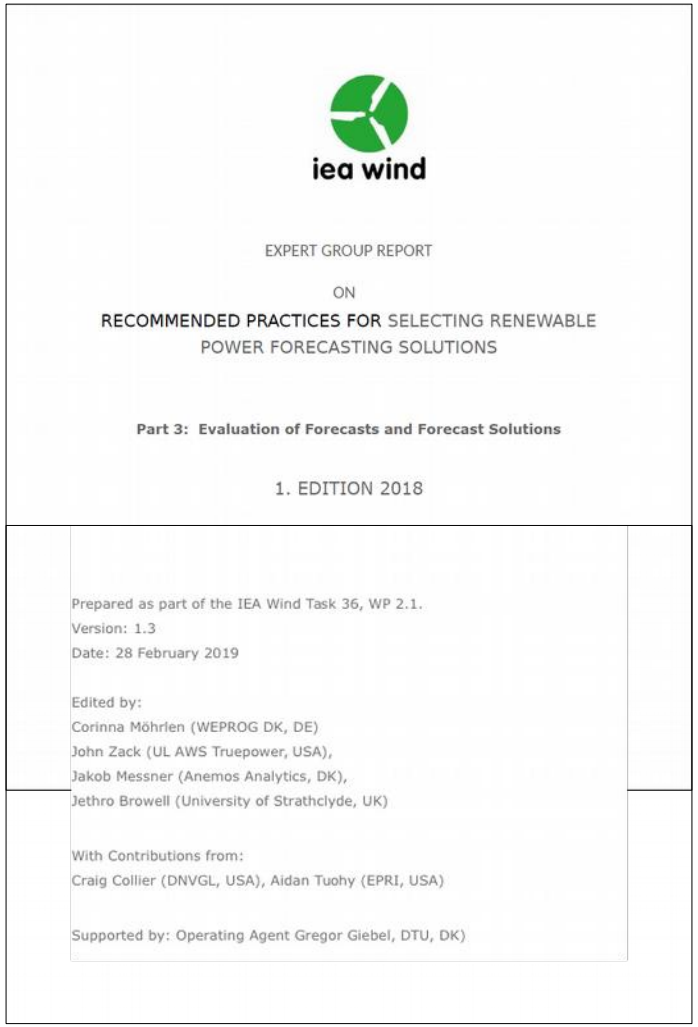
Supported by: Operating Agent Gregor Giebel (DTU, DK)

Part 3: Evaluation

- Presents the three key attributes of an evaluation process
- Discusses the factors and issues that should be considered for each attribute
- Provides recommendations for conducting a high quality and meaningful evaluation



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EXPERT GROUP REPORT

ON

RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 3: Evaluation of Forecasts and Forecast Solutions

1. EDITION 2018

Prepared as part of the IEA Wind Task 36, WP 2.1.
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Edited by:
Corinna Möhrlen (WEPROG DK, DE)
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16 - 18 Oct 2019
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Yesterday's OpenSpace Workshop

on

Wind Power Forecasting
& System Integration Issues

IEA Task 36 Open Space Workshop on Wind Power Forecasting & System Integration Issues

Organised by:

C. Möhrlen	WEPROG
J. Zack	UL-AWS Truepower
W. Shaw	PNNL
A. Kaiffel	ZSW-BW
S. Vogt	Fraunhofer IEE
J. Koch	Fraunhofer IEE
A. Wessel	Fraunhofer IEE

17th October 2019 – Session 6c

Time	Activity
16:10 - 16:30	Introductory presentation on IEA Wind Task 36 & explanation of workshop format and objectives
16:30 – 17:45	Open Space discussions in 5 groups - participants rotate free among the groups
17:45 – 18:15	Group leaders provide summary of each group to the full group; full group discussion

Open Space Topics

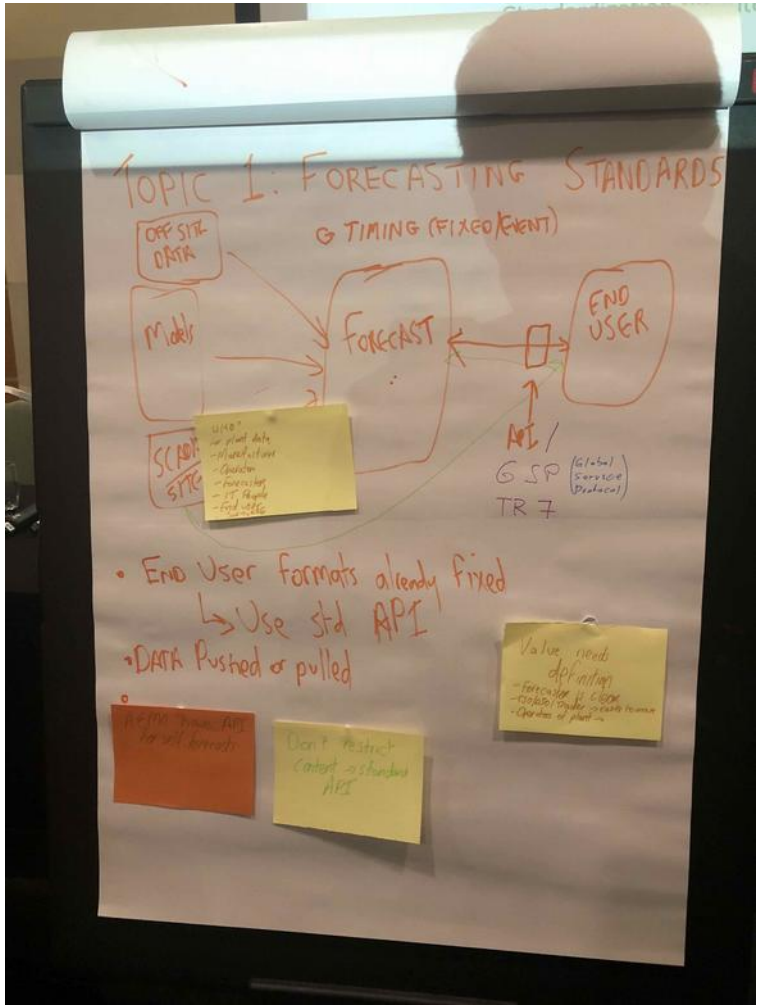
Topic #	Title
1	Standards and Recommended Practices for Data Exchange and IT Solutions in the Power Industry: Where do we need them?
2	Meteorological Measurements and Instrumentation Standardization for Integration into Grid Codes: What Can We Learn from the WMO?
3	Application of Probabilistic Forecasts in Grid Operation and Marketing: What Should a Guideline Contain?
4	Recommended Practices on Forecast Solution Selection: Which Areas Are Not Covered Sufficiently?
5	Uncovering Uncertainty Origins through the Entire Modelling Chain: Which Applications Can Benefit from That Knowledge?

Summary of OpenSpace Workshop Topic 1:

Standards and Recommended Practices for

Data Exchange and IT Solutions in the Power Industry: **Do we need them?**

- **Consensus: yes, would help both forecasters & end users**
- **Need to clearly define value for all potential stakeholders**
  - End users: ability to switch forecasts, spin up quickly, and take advantage of improvements
  - Forecasters: startup costs are lower, can enter new markets, judged on skill
  - Others: wind plant owners could use this to support operations
- **Hard to be able to change processes at many end users**
  - Potential solution would be API to sit between forecasters and users
  - Examples might include AEMO recent API for self forecasting & German Global Service Protocol
  - Shouldn't restrict content of a standardized API
- **Important to recognize that forecasts may be regularly scheduled (as with most users) or event driven (many forecasters, e.g. for new NWP run)**
  - Data could be pushed or pulled and this should also be reflected

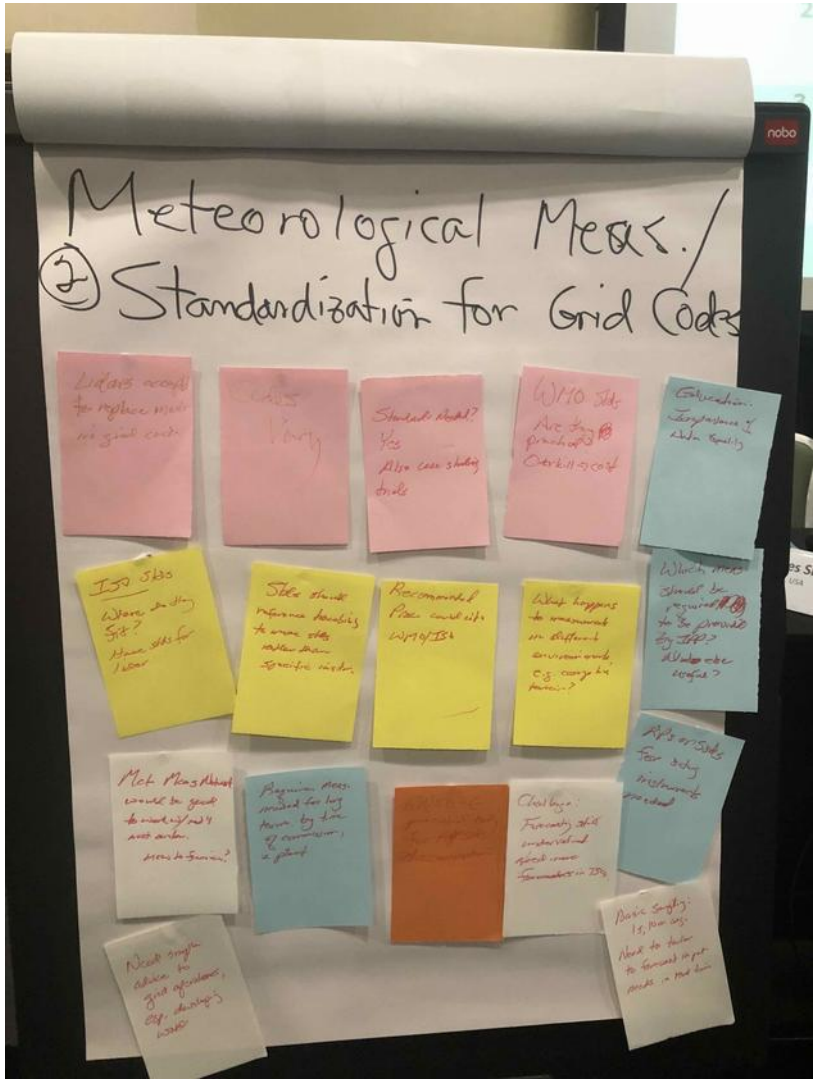


Summary of OpenSpace Workshop Topic 2:

Meteorological Measurements and Instrumentation

Standardization for Integration into Grid Codes: **What Can We Learn from the WMO?**

- **General Agreement that Standards/RPs are Needed**
  - Grid codes vary from region to region
  - Concern about adopting WMO or similar standards, which may be expensive overkill for grid code purposes
  - Should reference traceability to standards but be instrument agnostic
  - Could suggest required measurements by IPPs at time of commissioning
  - Need education on importance of data quality
  - Need to address site selection for instrumentation
  - Need to tailor reporting interval to forecast model input needs
- **Dissemination**
  - No consensus on how to accomplish
  - ENSO-E is a potential body for dissemination
  - Forecasting still undervalued. Need more forecasters in TSOs.
  - Need simple advice to give operators, especially in the developing world



Summary of OpenSpace Workshop Topic 3:

Application of Probabilistic Forecasts in Grid Operation and Marketing:

What Should a Guideline Contain?

Explain Methodologies

- clearly state (dis-)advantages of different ensemble creation models

Black-box methods

- Can methods like machine learning be trusted ?
- A guideline might help industry to trust

Visualisation of probabilistic forecasts

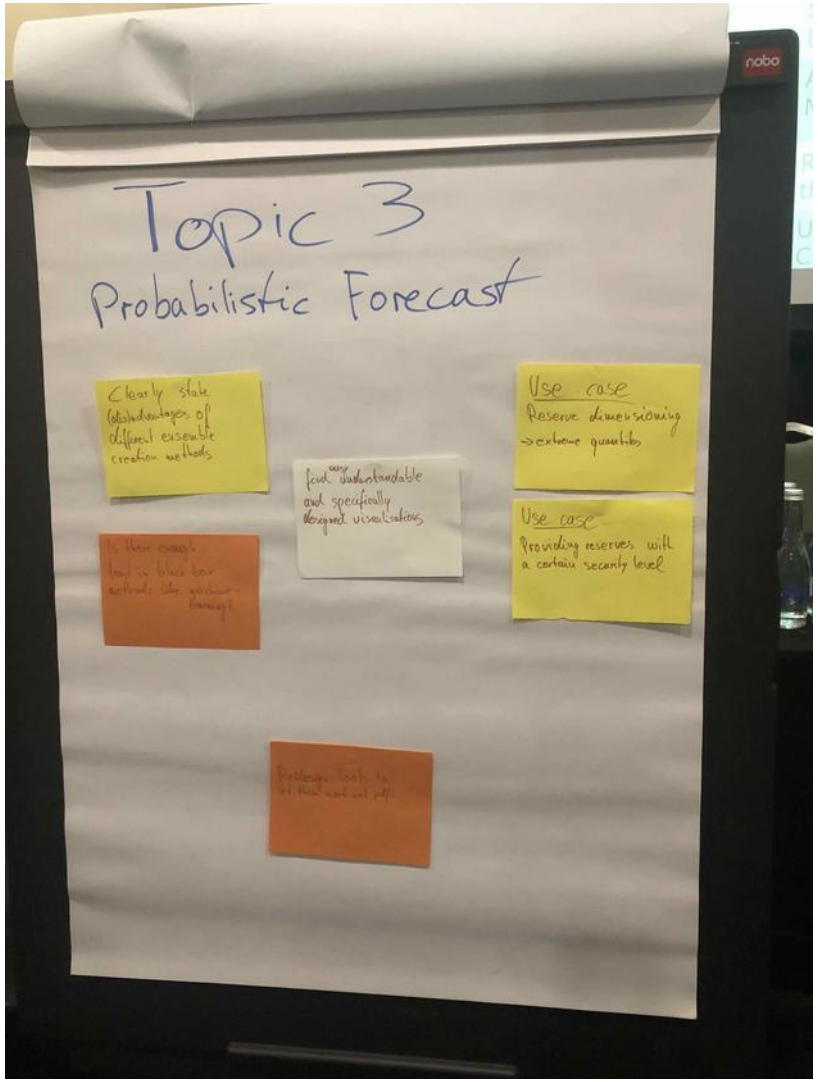
lack of understandable and specifically designed visualisations

Redesign Tools to provide raw probabilities (PDFs)

Give industry the “raw” data and design software to enable end-users to use that data across their applications

Use cases:

- (Ramping) Reserve dimensioning → extreme quantiles
  → provision with security levels/risk

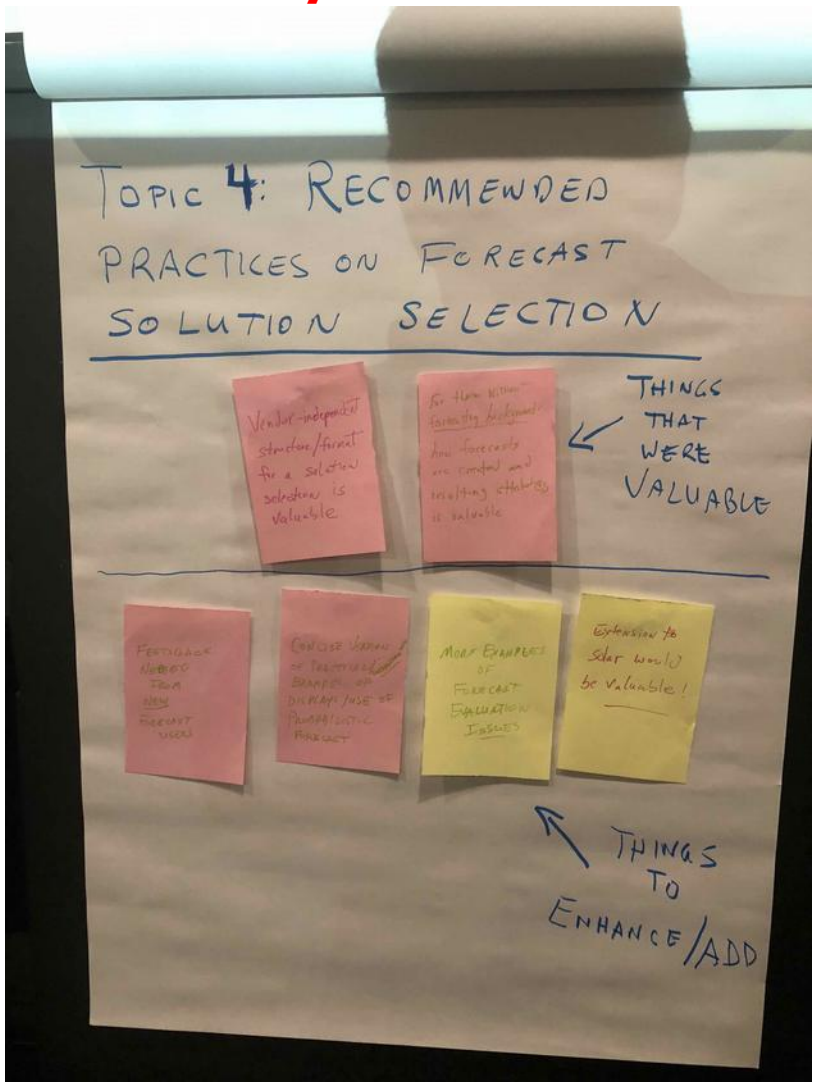


Summary of OpenSpace Workshop Topic 4:

Recommended Practices on Forecast Solution Selection:

Which Areas Are Not Covered Sufficiently?

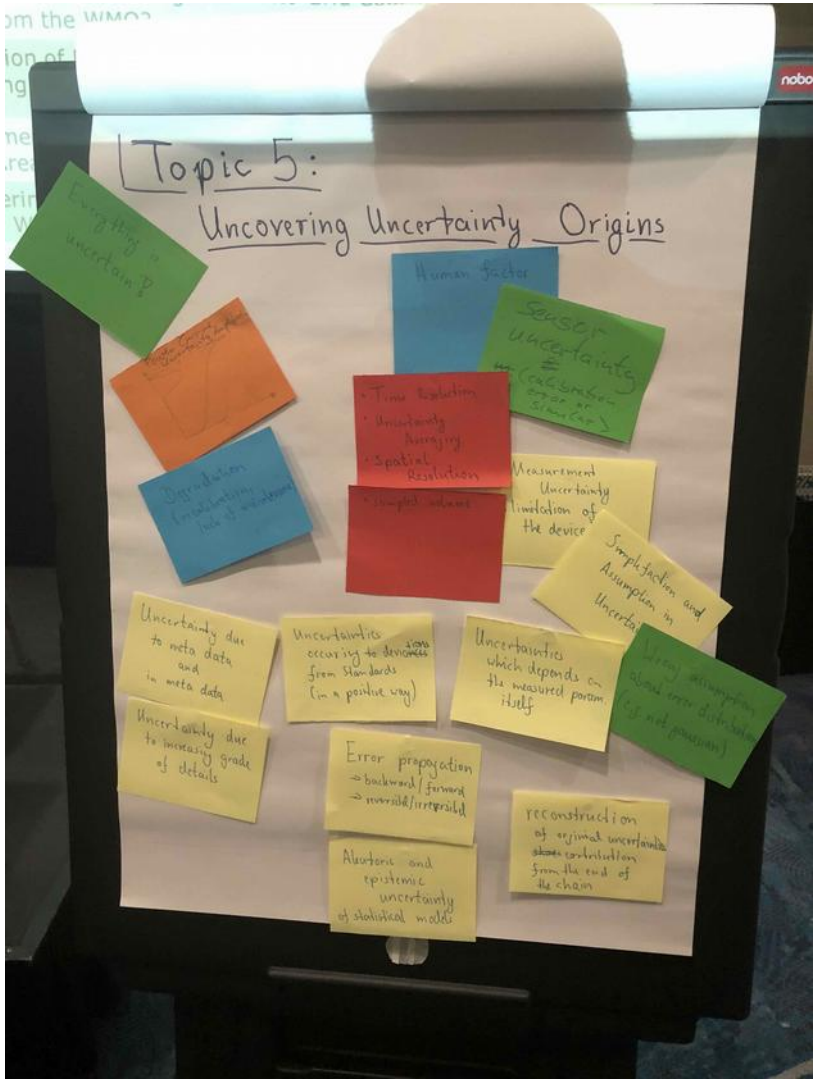
- **User Feedback: Especially Valuable Components**
  - Forecast-vendor-independent guidance about the design and implementation of a process to select an optimal forecast solution
  - Forecast-vendor-independent information about the range of state-of-the-science methods used by forecast providers and the key attributes of the methods that impact end users
- **Suggestions for Enhancement & Additions**
  - Obtain feedback from the most novice users (e.g., grid operators in developing countries)
  - Intuitive real case examples to develop a perspective of value and need for probabilistic forecasts (i.e. “I want to have this!”)
  - More examples to intuitively illustrate forecast evaluation issues
  - Extend the documents to include solar-specific forecast issues



Summary of OpenSpace Workshop Topic 5:

Uncovering Uncertainty Origins through the Entire Modelling Chain:
Which Applications Can Benefit from That Knowledge?

- **Uncertainties handling in the context of Error Theory**
  - Uncertainty/Error Propagation
  - Uncertainty following no Gaussian distributions
  - Reverse estimation of the original error from a combined value
- **Uncertainties in the measurement process**
  - Degradation
  - Calibration
- **Uncertainties through device design**
- **Human factor**
  - Missing or wrong meta data
  - Maintenance
- **Uncertainties due to Scale, Dimension and Processing**
  - Averaging
  - Timescale
- **Oberserved Volume/Area**
  - Spatial Distance
- **Uncertainties due to simplifications**
  - caused by the process of reducing complexity



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Topic 5:

Where to get the details…?

Work Package 2 Publications

Best Practices Documents

ESIG Forecasting Workshop

2017 and 2018

2 Sessions

10 Presentations

Wind Integration Workshop

2 Workshop Papers

4 Workshop Presentations

YouTube Channel

1 Webinar

All papers and presentations are publicly available on the web:

→ **Task 36 site**

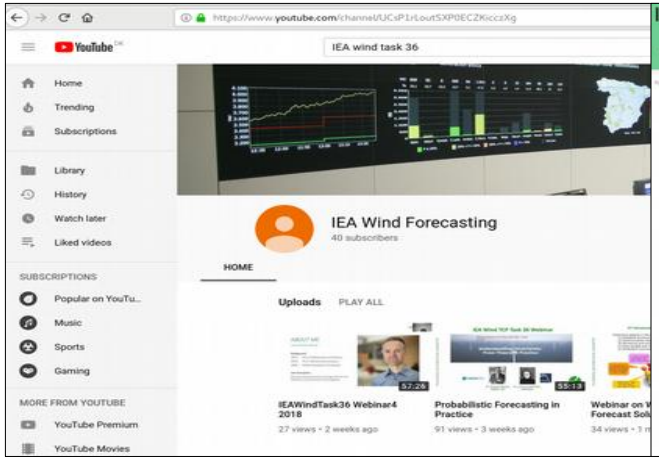
- ieawindforecasting.dk

→ **Research Gate Project**

- www.researchgate.net/project/IEA-Wind-Task-36-Wind-Power-Forecasting

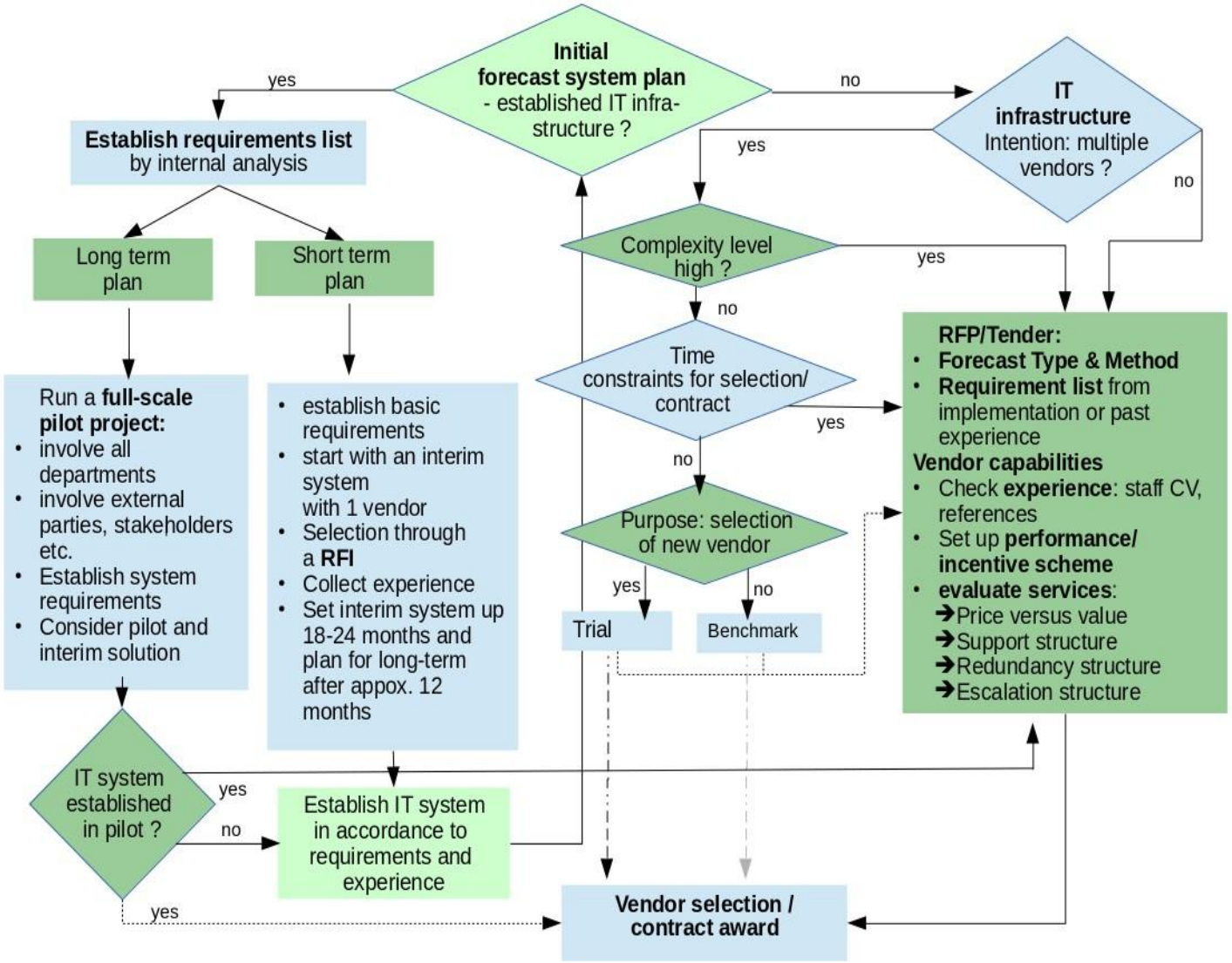
→ **IEA Wind Forecasting YouTube Channel:**

- www.youtube.com/channel/UCsP1rLoutSXP0ECZKicczXg



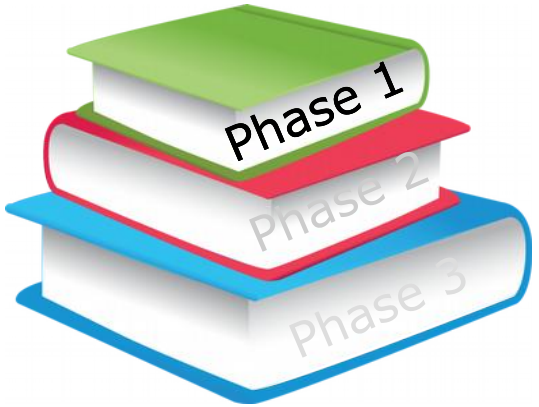
Additional Information

Decision Support Tool for the Process of Selecting a Forecasting Solution



- Provides guidance and practical examples for:
  - the formulation of a process to select an optimal forecasting solution
  - analysis and formulation of forecasting requirements
  - assessing vendor capabilities with and without trials

The 3 Phases of a Benchmarking Process: #1



Preparation Phase:
determining the scope and focus of the performance evaluation

Forecast horizons (look-ahead time periods)

Available historical data

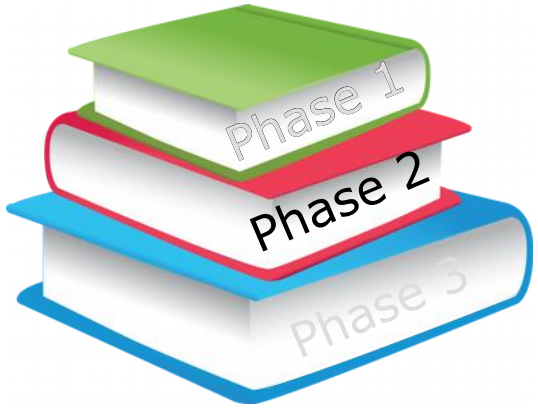
Appropriate length of benchmark

Are conditions during benchmark **representative?**

Meaningful evaluation metrics

Think of what factors are most important as in any big or long-term purchase (e.g. home, car, forecasting system)?

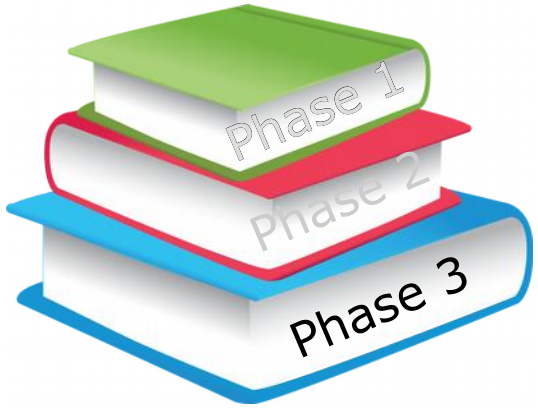
The 3 Phases of a Benchmarking Process: #2



Execution Phase:
ensuring a fair and representative process

- Data monitoring (forecasts and observations)
- For fairness and transparency: test accuracy and delivery performance.
- Monitor forecast receipt (reliability)
- Sample should be normalized (all forecasters evaluated for same period & locations)
- Develop and refine the evaluation scripts

The 3 Phases of a Benchmarking Process: #3



Analysis Phase:

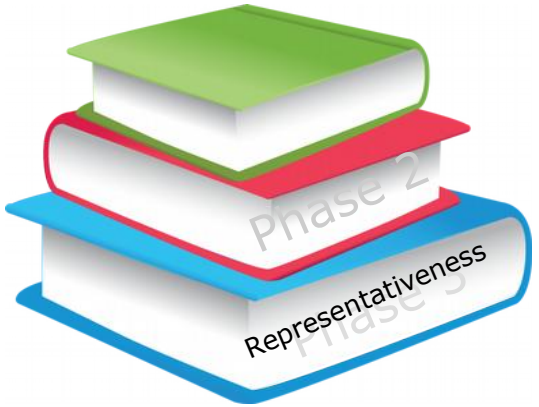
compiling a comprehensive and relevant assessment

- **Critical Evaluation Criteria:**
  - Application-relevant accuracy of the forecasts
  - Performance in the timely delivery of forecasts
  - Ease of working with the forecast provider

Examples of Benchmarking Pitfalls to Avoid

- **Poor communication with forecast providers**
  - All forecast providers should be provided with the same information
  - Incumbent providers should not by default have an information advantage
- **Unreliable comparisons**
  - Forecasts for different time periods are compared (evaluated)
  - Forecasts for different facilities/portfolios are compared (evaluated)
- ***Bad design***
  - Short trials in unrepresentative periods (e.g. 1 month in a low wind season)
  - No on-site data given to forecast providers
  - Intra-day forecasts made from once-a-day target-site data update
- ***Details missing or not communicated to providers***
  - No documentation of daylight savings time changes in data files
  - No specification of whether time stamp represents interval beginning or ending
  - No documentation of plant capacity changes in historical data or trial period
  - Curtailment and maintenance outages not provided
- ***Opportunities for "cheating" not eliminated***
  - No penalty for missing forecasts (possible no submission in difficult situations)
  - Forecast delivery times not enforced (could submit later forecasts)

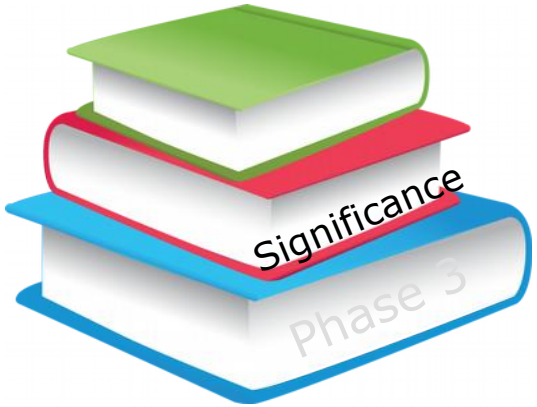
Three Critical Factors to Achieve a Meaningful Trial: #1



Representativeness: relationship between the results of a forecast performance evaluation and the performance that is ultimately obtained in the operational use of a forecast solution

- Statistically meaningful evaluation sample size and composition
- High quality data from the forecast target sites
- Formulation and enforcement of rules governing the submission of forecasts (“fairness”)
- Availability of a complete and consistent set of evaluation procedure information to all evaluation participants (“transparency”)

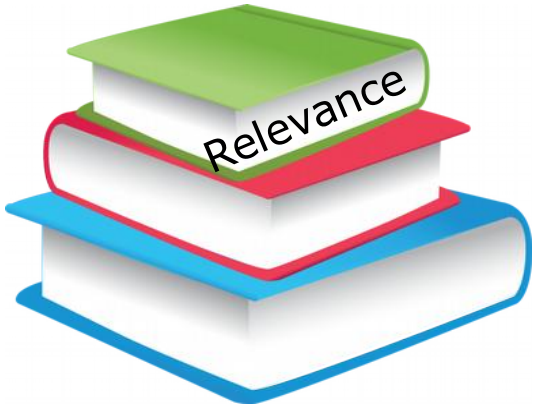
Three Critical Factors to Achieve a Meaningful Trial: #2



Significance: ability to differentiate between performance differences that are due to noise in the evaluation process and those that are due to meaningful differences in skill among forecast solutions

- Minimize noise in the evaluation sample (i.e. lower the uncertainty)
- Quantify the uncertainty in performance metrics
- Consider performance uncertainty bands when evaluating performance differences among candidate solutions

Three Critical Factors to Achieve a Meaningful Trial: #3



Relevance: degree of alignment between the evaluation metrics used for an evaluation and the true sensitivity of a user's application(s) to forecast error

- **Ideal Approach**: formulate a cost function that transforms forecast error to the application-related consequences of those errors (often very difficult)
- **Practical Alternative**: use a matrix of performance metrics that measure a range of forecast performance attributes
- **When using more than one relevant metric:**
  - Remember: ONE forecast can NOT be optimal for more than one metric;
  - Use separate forecast optimized for each metric if that attribute of performance is critical
- **When employing multiple ("N") forecast solutions:** choose the set that provides the best composite performance NOT the "N" best performing solutions

Key Points

- *All performance evaluations of potential or ongoing forecast solutions have a degree of uncertainty*
- *The uncertainty is associated with three attributes of the performance evaluation process evaluation process: (1) representativeness, (2) significance and (3) relevance*
- *A carefully designed and implemented evaluation process that considers the key issues in each of these three attributes can minimize the uncertainty and yield the most meaningful evaluation results*
- *A disregard of these issues is likely to lead to uncertainty and/or decisions based on unrepresentative information*