IEA Wind Task 36 Workshop on
Best Practice in the Use of Forecasting in the Power Industry
University of Strathclyde, Glasgow, Scotland
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IEA Wind Recommended Practice on Renewable Energy Forecast Solution Selection

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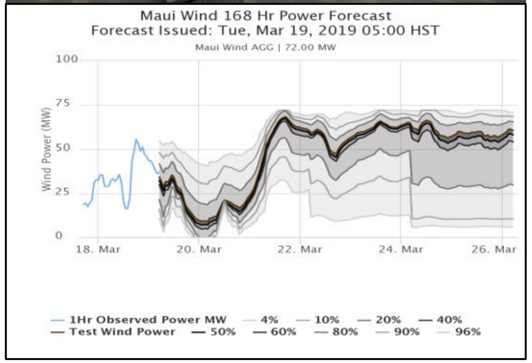
Overview of Presentation

1. The Problem and an Approach to a Solution
2. Background: IEA Task 36 – Wind Forecasting
3. Overview of IEA Best Practices for Forecasting Solution Selection
4. Key Points from the Best Practices Documents
5. Where to Get the More Information

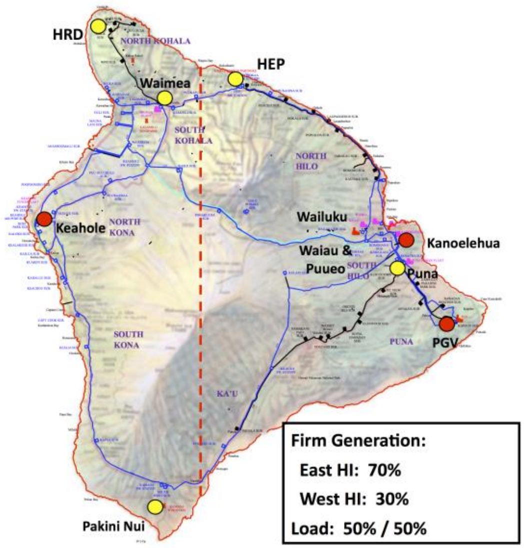
Topic 1: The Problem and an Approach for a Solution

- **Documented Benefits:** Use of forecasts to assist in the management of the variability of wind-based (and solar-based) generation can lower variable generation integration (system) costs while maintaining the required 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
    - Specification of the wrong forecast performance objective(s)
    - Poorly designed and executed benchmarks/trials of alternative solutions
    - Use of non-optimal evaluation metrics for forecast evaluation



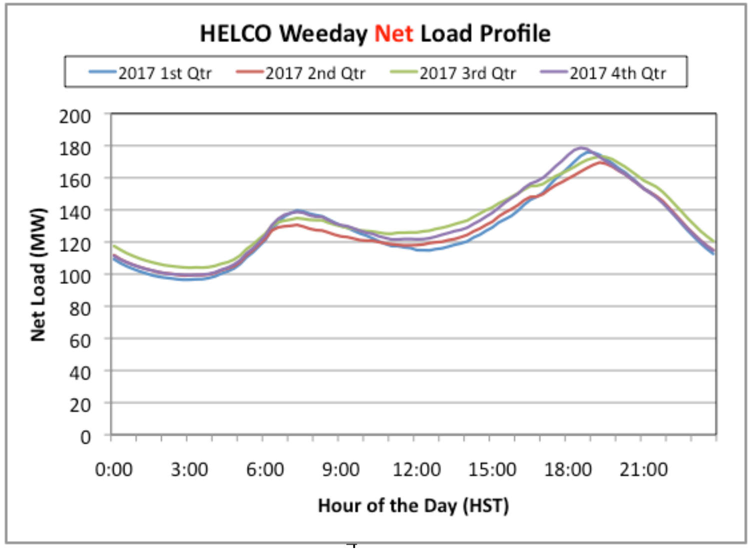
Misaligned Forecast Objectives:
An Example from the “Big Island” of Hawaii

SYSTEM OVERVIEW



Renewable Resource	Capacity
Geothermal (1 facility)	38 MW
Hydro (3 facilities)	16.2 MW
Wind (2 facilities)	31 MW
Solar (BTM Distributed)	90 MW

- **Weekday Net load: 2 daily peaks**
  - Morning (~0800): 130-140 MW
    - Morning rise in gross load followed by morning rise in PV production
  - Evening (~1800): 170-180 MW
- **Weekday Net load: 2 daily minima**
  - Nighttime (~0300): 95-105 MW
  - Daytime (~1200): 115-125 MW
    - Associated with peak of distributed PV



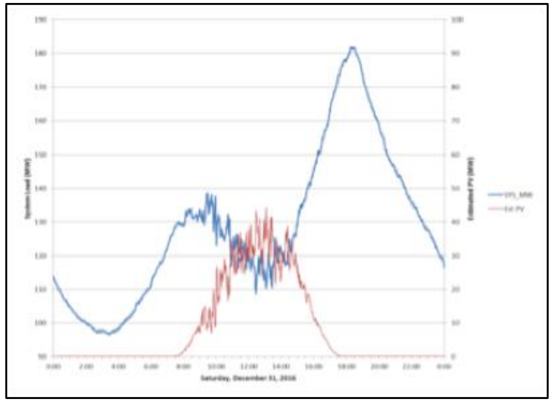
Misaligned Forecast Objectives: An Example from the "Big Island" of Hawaii

WHAT THEY REQUESTED VS. WHAT THEY NEED

REQUESTED: Forecasts that minimize the squared error for every 15-min interval (based on quantile regression)

- Produced from multi-method (NWP, statistical, satellite cloud advection) forecast ensemble
- Two Forecast Time Frames
  - **Intra-day**
    - 0-6 hrs ahead in 15-min time steps
    - 15-min updates
  - Multiple Day
    - 0-7 days ahead in 1-hr time steps
    - 1 hr updates
- **Resulting Forecast Attributes**: phase and amplitude errors in small scale cloud features at 15-min scale force squared error optimization to create a smooth forecast (minimal temporal variability)

Issue: large mid-day net load variability driven by distributed PV variability



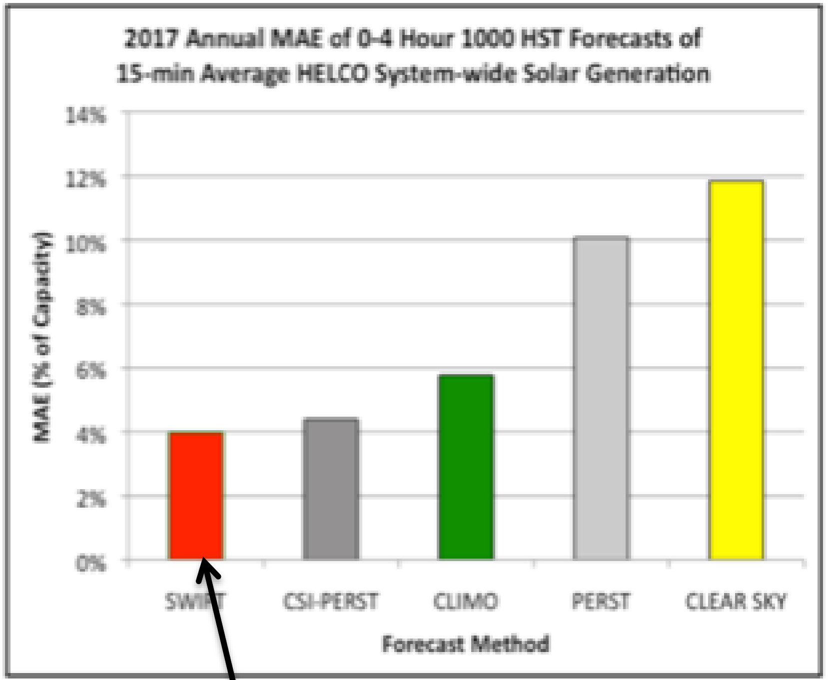
- Adequate ramping capability must be available with the online units to ensure that the system frequency doesn't go too high or too low
- Key Question: What will be the optimal mix of online and offline (quick-start) ramping resources for the midday period?

NEED: Mid-day (1000-1400) range of variability forecast (not necessary to have each 15-min period correct – just the generation envelope)

Misaligned Forecast Objectives:
An Example from the "Big Island" of Hawaii

THE RESULT

Mean Absolute Error (or RMSE) looks good!

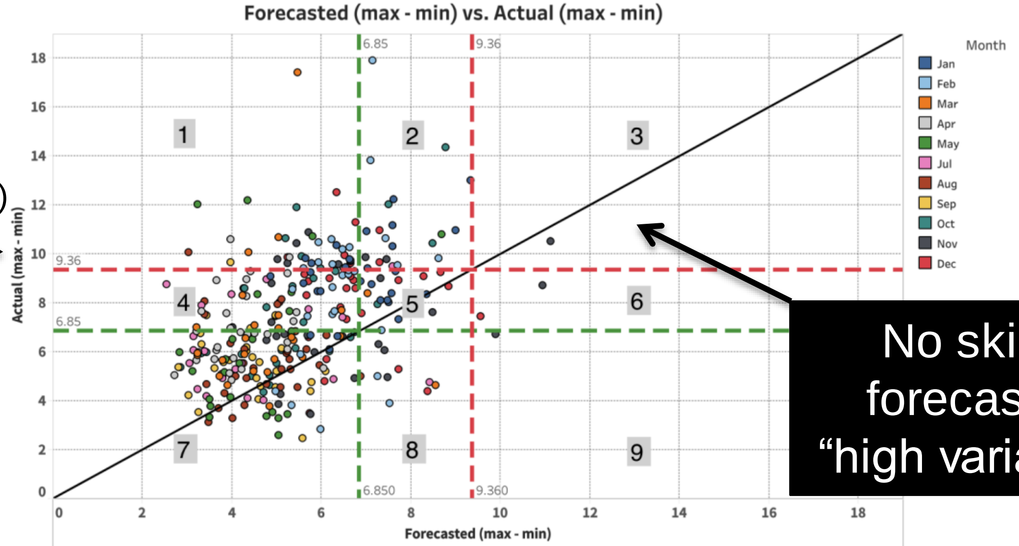


MAE for 0-4 hr forecasts for mid-day period is 4 % of Capacity and 15% lower than "smart persistence"

Same period (2017)

Prediction of Variability is Inadequate for Decision-Making on Mid-day Reserves

Actual vs. Forecasted Mid-day Range of 15-min Solar Gen (MW)



No skill at forecasting "high variability"

Count	Forecasted				
Observed	Category	Low	Moderate	High	Obs %
	High	40	21	1	20.0%
	Moderate	72	20	2	30.3%
	Low	143	10	1	49.7%
	Forecast %	82.3%	16.5%	1.3%	100.0%

To Address this Issue: International group of experts have interacted under the framework of IEA Wind Task 36 to formulate a set of documents that specify the “best practices” for selecting a renewable energy forecasting solution…….

Topic 2: IEA Task 36 - Forecasting for Wind Energy

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

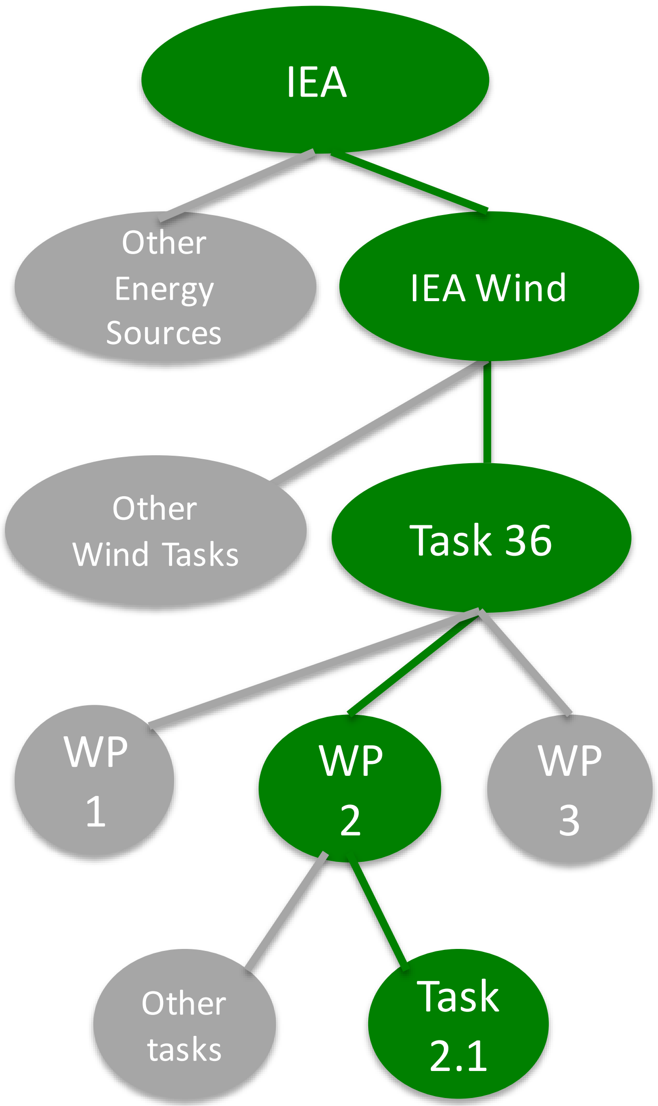
- International organization within OECD with 30 members countries and 8 associates
- Promotes global dialogue on energy, providing authoritative analysis through a wide range of publications
- **One activity: convenes panels of experts to address specific topics/issues**

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

- One of several ongoing Tasks of IEA Wind: https://community.ieawind.org/home
- Phase 1 started in 2016 for 3 years; Phase 2 began in 2019 for additional 3 years
- Operating Agent is Gregor Giebel of DTU Wind Energy
- Objective: facilitate improvements in performance and **value of 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
    - **Task 2.1: Recommended Best Practices for Forecast Solution Selection**
- WP3: Usage of Probabilistic Forecasts and Scenarios



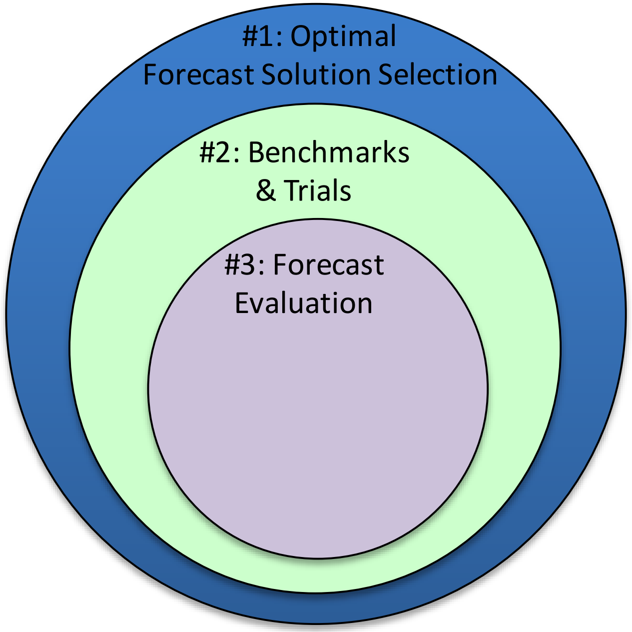
Topic 3: Structure and Content of the “Best Practices” Documents

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

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

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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

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

- Part 1: Selection of an Optimal Forecast Solution

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RECOMMENDED PRACTICES 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

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

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RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 3: Evaluation of Forecasts and Forecast Solutions

1. EDITION 2018

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

- 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

Topic 4: Key Points from Each Part

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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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

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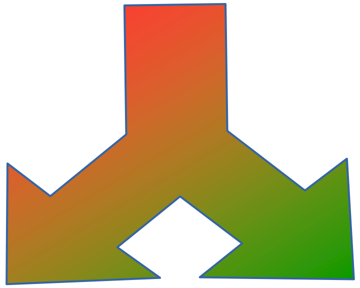
Key Elements of Recommended Practices for Forecast Solution Selection

- Selection/update of forecasting solutions in which **Quality, Reliability and Price** are in perfect harmony is usually a complex task

- Forecast IT infrastructure and solution architecture need careful considerations



→provides decision support for basic elements common to all forecast solutions

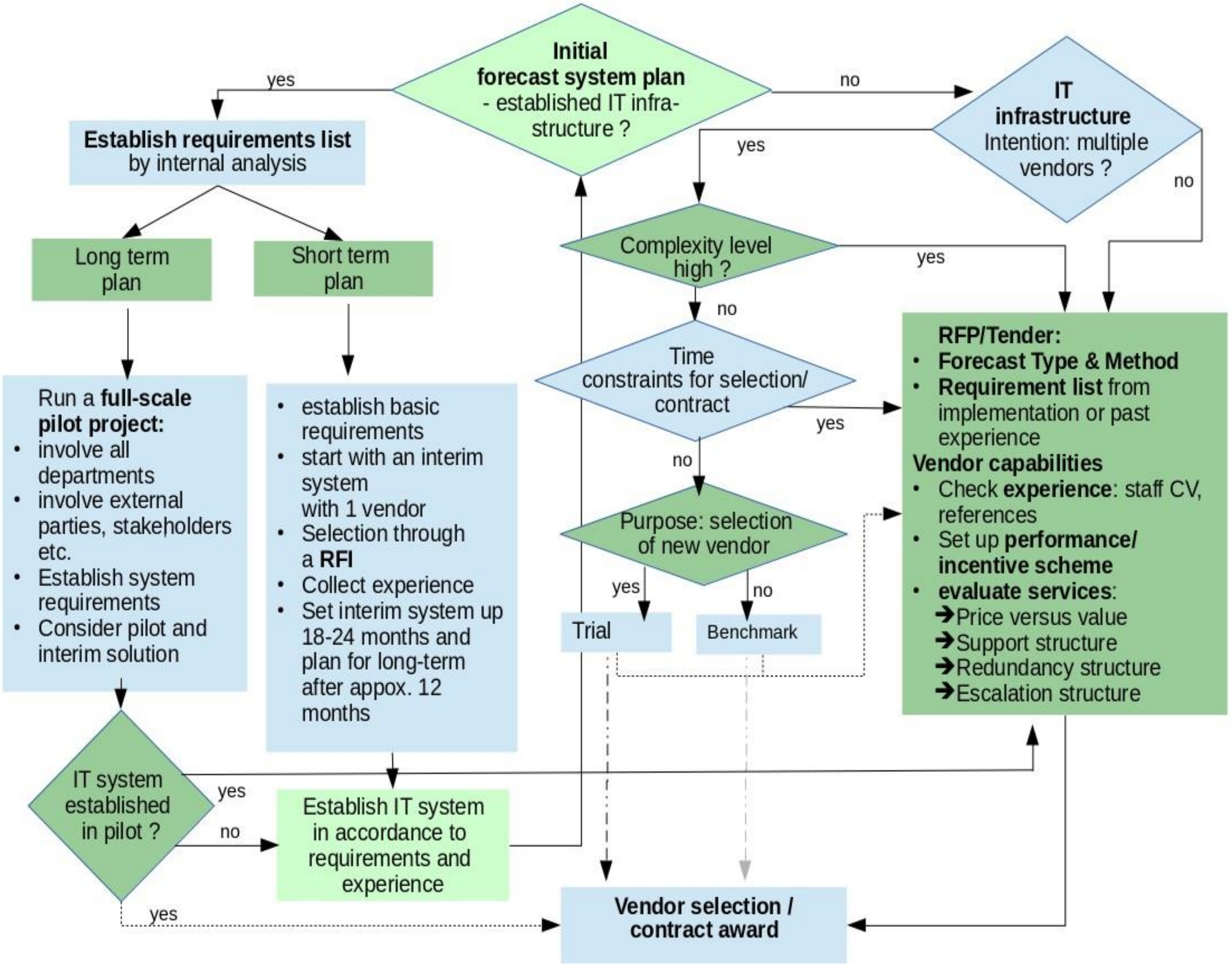
→encourages end-users to analyze their own situation

→encourages users to request a forecasting solution that fits their own purposes

→ discourages to just "do what everybody else is doing"

→ discourages seeking a simple or cheap solution if the application is complex

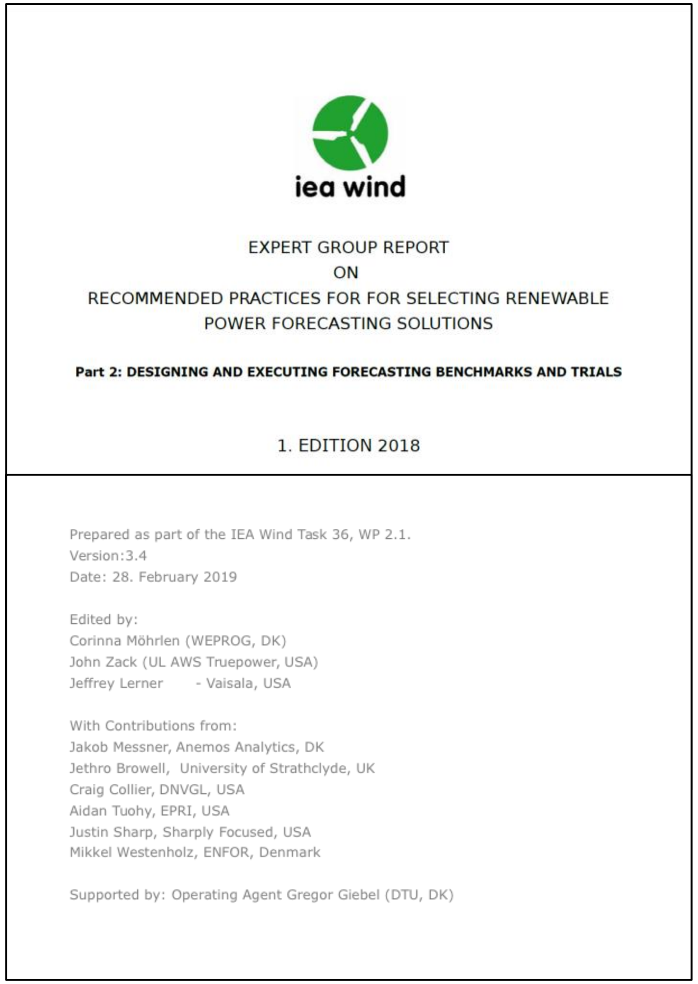
Decision Support Tool for the Process of Selecting a Forecasting Solution



- 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

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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RECOMMENDED PRACTICES FOR FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 2: DESIGNING AND EXECUTING FORECASTING BENCHMARKS AND TRIALS

1. EDITION 2018

Prepared as part of the IEA Wind Task 36, WP 2.1.
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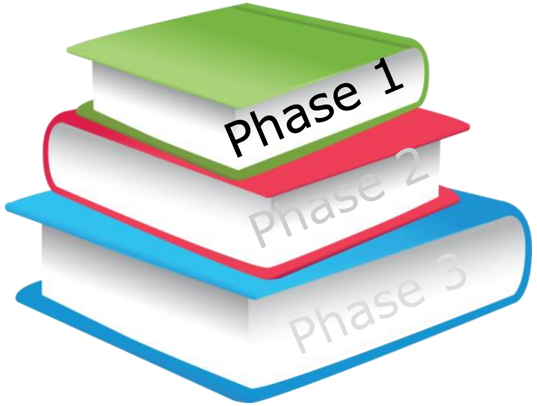
The 3 Phases of a Benchmarking Process: #1



Preparation Phase:

determining the scope and focus of the performance evaluation

Forecast horizons (look-ahead time periods)

Available historical data

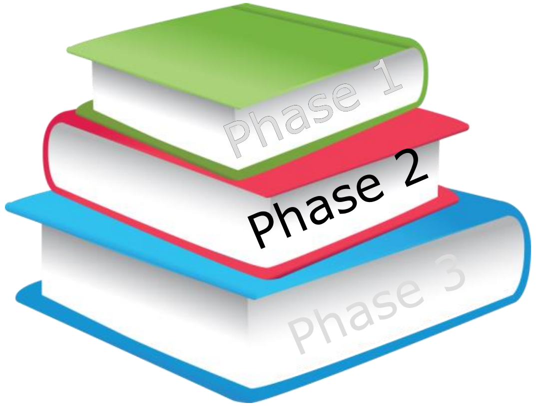
Appropriate length of benchmark

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

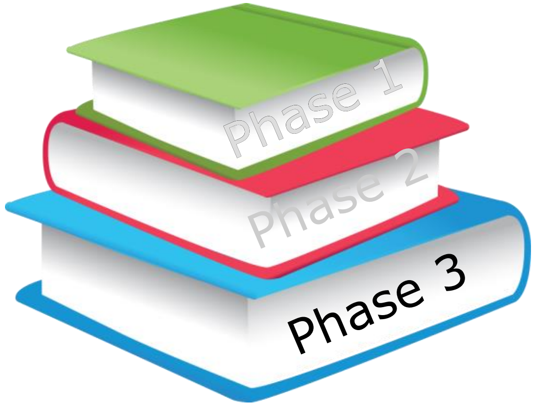


Execution Phase:

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)

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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RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 3: Evaluation of Forecasts and Forecast Solutions

1. EDITION 2018

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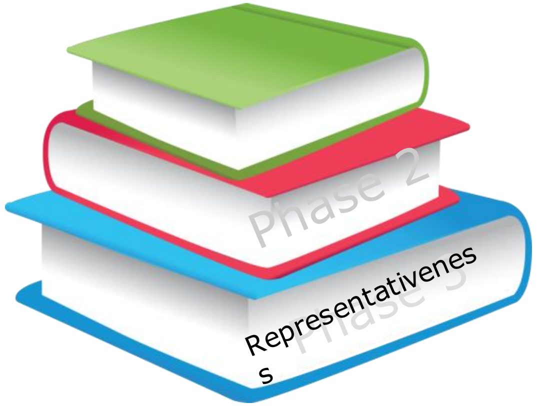
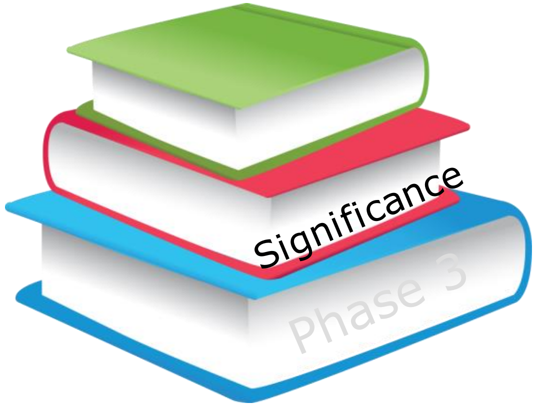
Three Critical Factors to Achieve a Meaningful Trial: #1



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”)

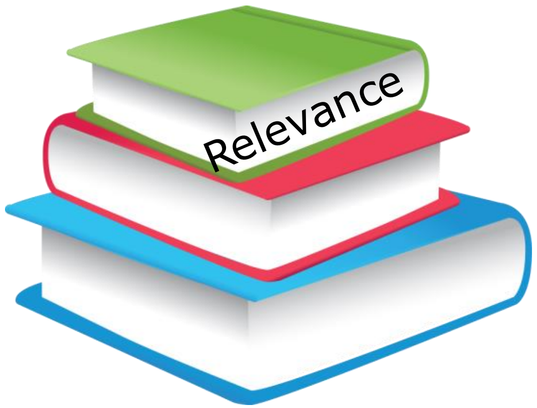
Three Critical Factors to Achieve a Meaningful Trial: #2



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

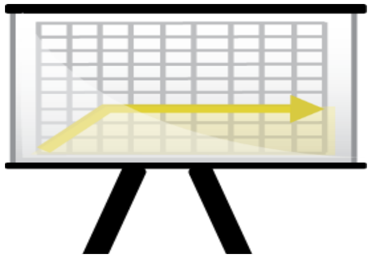


Relevance: degree of alignment between the evaluation metrics used for an evaluation and the true sensitivity of a user's application(s) to forecast error

- **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

Evaluation Paradigm

- **Verification is subjective:**
  it is important to understand the limitations of a chosen metric

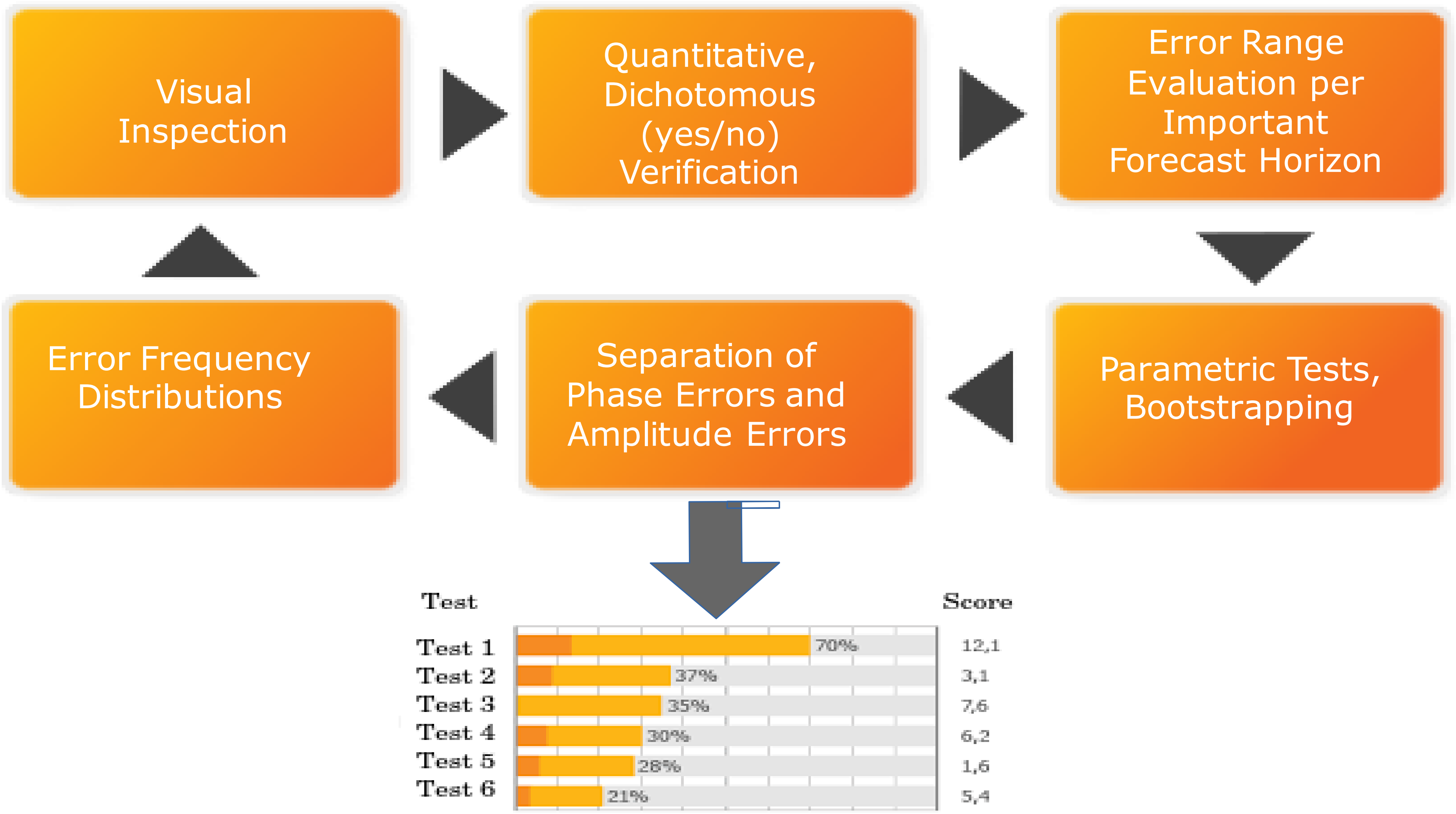


- **Verification has an inherent uncertainty:**
  due to its dependence on the evaluation data set

- **Evaluation should contain a set of metrics:**
  in order to measure a range of forecast performance attributes

- **Evaluation should reflect a "cost function":**
  the metric combinations should provide value of solution

Evaluation with Verification Methods – Development of "Cost Functions" -



Performance Evaluation: 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

Key Takeaways
(from each part of the RP Series)

1. Solution selection process:

Use a *Decision Support Tool* to establish a procedure

2. Benchmarking:

Setup a representative, transparent and fair test with good user-provider communication

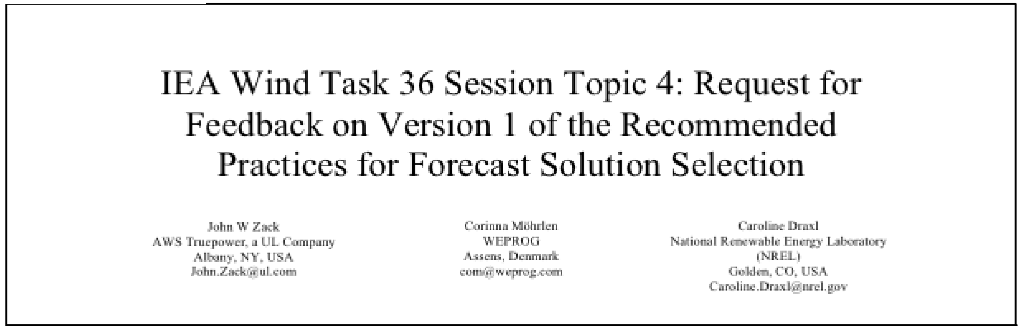
3. Evaluation:

Develop a "cost function" or use an "evaluation matrix" of different scores according to their importance

RP-related Plans for Phase 2: 2019-2021

- *Communicate content and provide Workshops to help industry to adopt practices*
  - *Plans to present overview at several industry gatherings in 2020*
  - *Plans for an implementation workshop*
- *Obtain feedback on usefulness of RP from the community*
  - *Target: get feedback from new or inexperienced forecast users (individual or organizations)*
  - *Task 36 Open Space workshops held at WIW-2019 and ICEM-2019*
- *Expand the Scope of the RP*
  - *Probabilistic forecast use and evaluation*
  - *Include more examples of issues and solutions*

Topic 5: Where to Get More Information


IEA Wind Task 36 Session Topic 4: Request for Feedback on Version 1 of the Recommended Practices for Forecast Solution Selection

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RP-related Publications

RP Documents:
http://www.ieawindforecasting.dk/Publications

2019 Wind Integration Workshop (Dublin)
Paper in Proceedings
Presentation

2019 ESIG (Denver)
Presentation

YouTube Channel
Webinar on Recommended Practices

Task 36 Information

→ **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