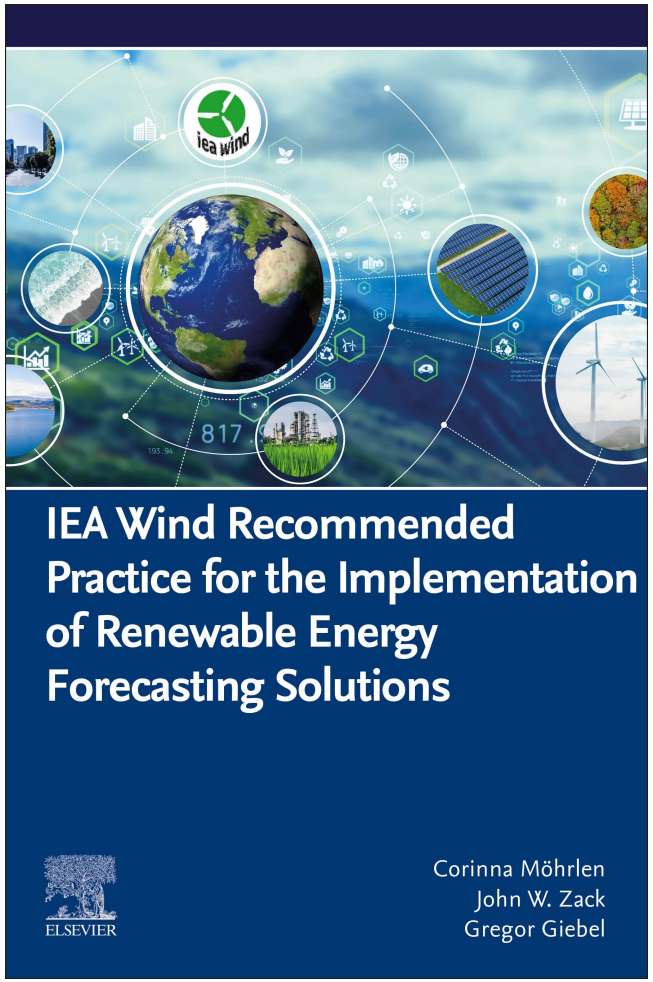
Task 36 Wind Energy Forecasting
Task 51 Forecasting for the Weather-driven Energy System



Introduction to IEA Wind's Recommended Practice for the Implementation of Renewable Energy Forecasting Solutions

International Conference on Energy and Meteorology
28 June 2023 – Padua, Italy

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Overview

- Background
  - What is IEA Wind and Tasks 36 and 51?
  - The Problem: How to select and maintain optimal wind/solar forecast solutions
- Overview of the Recommended Practice (RP)
  - Part 1: Selection Process and Data Communication
  - Part 2: Benchmarking and trials
  - Part 3: Evaluation
  - Part 4: Measurement Handling
- Where to Get the More Information

Background Information

What is IEA Wind and Tasks 36/51?

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
- **Sponsors Technology Collaboration Programmes (TCPs) on specific topics**

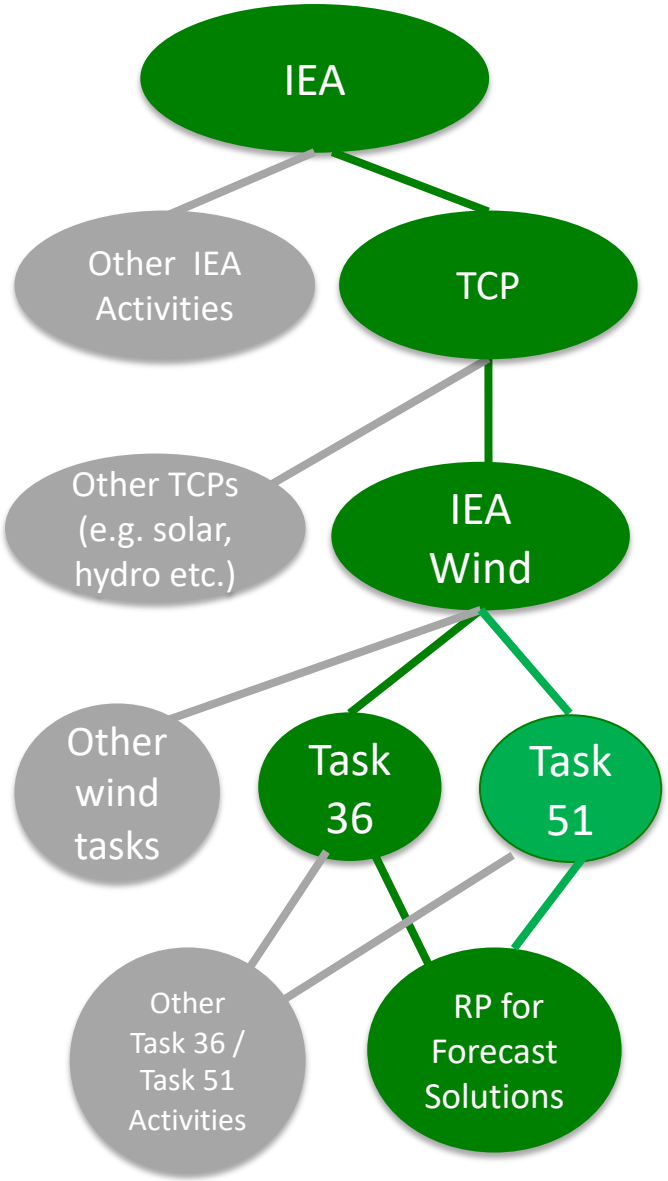
Task 36: Forecasting for Wind Energy:

- Objective: facilitate improvements in performance and **value of wind energy forecasts**
- Phase 1 was active from 2016 to 2018
  - Produced Version 1 of Recommended Practice for Selection of Forecast Solutions
- Phase 2 was active from 2019 to 2021
  - Produced Version 2 of Recommended Practice for Selection of Forecast Solutions

Task 51: Forecasting for the Weather Driven Energy System

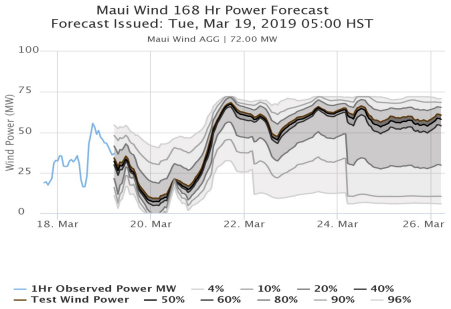
- Began in January 2022 and will be active for 4 years
- Broader perspective on forecasting applications but also continuing some Task 36 topics/activities
- We welcome additional collaborators in each of the Task 51 focus topics

More information: **https://iea-wind/org/task36** and https://iea-wind.org/task51



The Forecasting Solution Problem

- **Documented Benefits:**
  - lower costs of variable generation integration into electric systems
  - higher 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



- **To Address this Issue:**
  - International group of ~25 experts have interacted under the framework of IEA Wind Task 36 over 5 years (2016-2021) to formulate a set of recommendations that specify the “best practices” for selecting and maintaining a renewable energy forecasting solution

Overview of the RP – Version 2

The Result
Recommended Practices for the Implementation of Renewable Energy Forecasting Solutions

Target: Guidance for the optimal selection of renewable energy forecasting solutions for a wide range of user types and applications

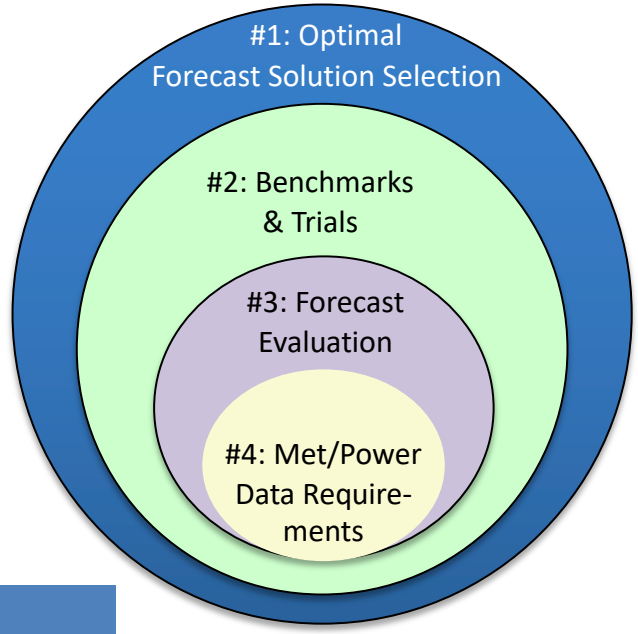
Result: Set of 4 documents specifying IEA Wind Recommended Practices for:

Selection of an Optimal Forecast Solution

Design and Execution of Benchmarks and Trials

Evaluation of Forecasts and Forecast Solutions

Meteorological and Power Data Requirements for real-time forecasting Applications

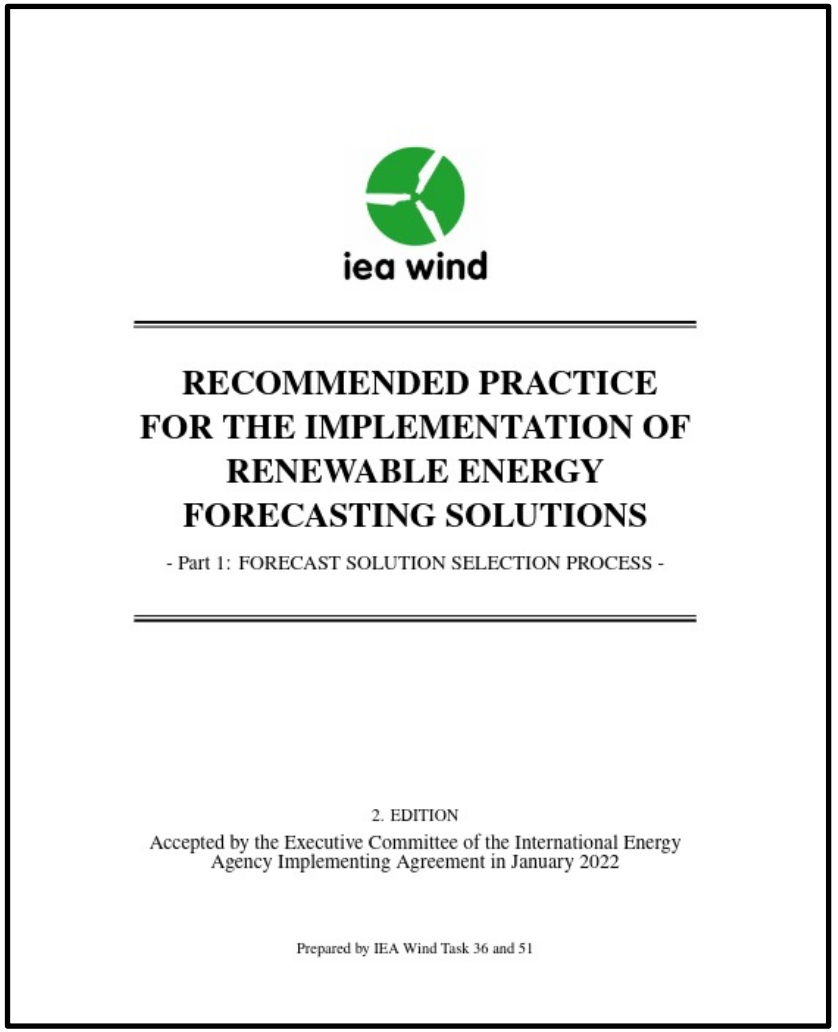


History: Version 1 published in 2019,
Version 2 accepted in Jan. 2022 – available since Feb. 2022
Published by Elsevier as an Open Access Book in Nov. 2022

Download: https://iea-wind.org/task51/task51-publications/task51-recommended-practices/

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 PRACTICE
FOR THE IMPLEMENTATION OF
RENEWABLE ENERGY
FORECASTING SOLUTIONS

- Part 1: FORECAST SOLUTION SELECTION PROCESS -

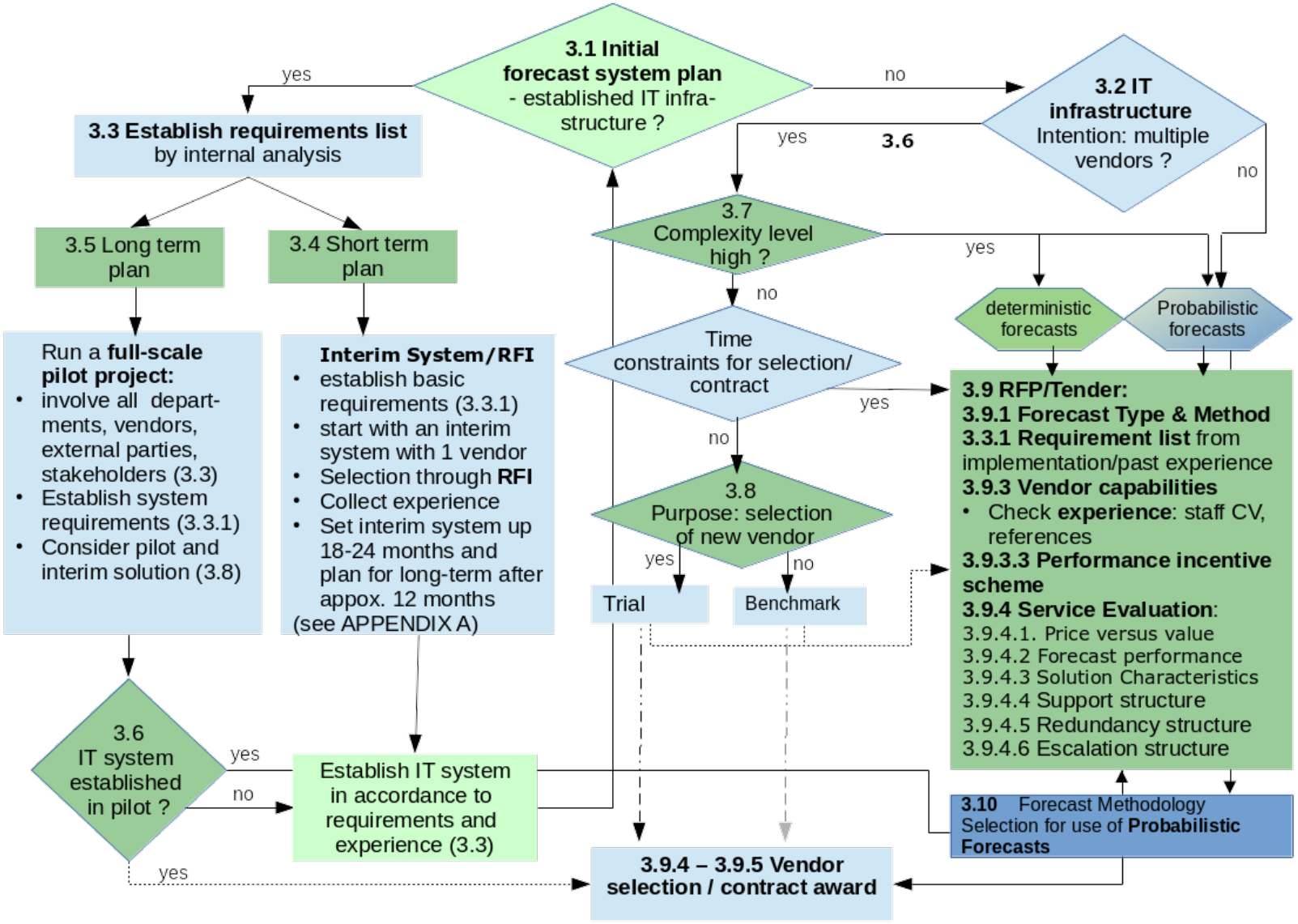
2. EDITION

Accepted by the Executive Committee of the International Energy Agency Implementing Agreement in January 2022

Prepared by IEA Wind Task 36 and 51

Part 1: Key Points

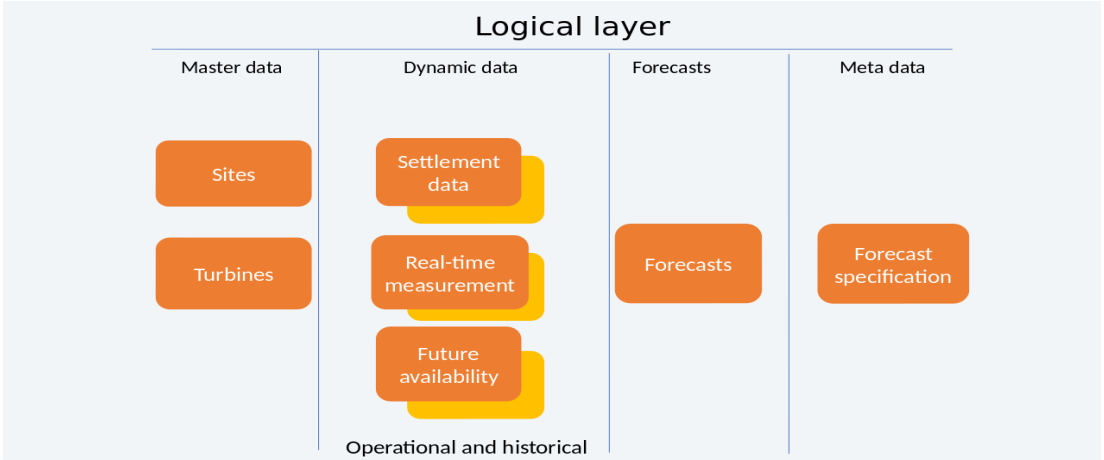
Decision Support Tool



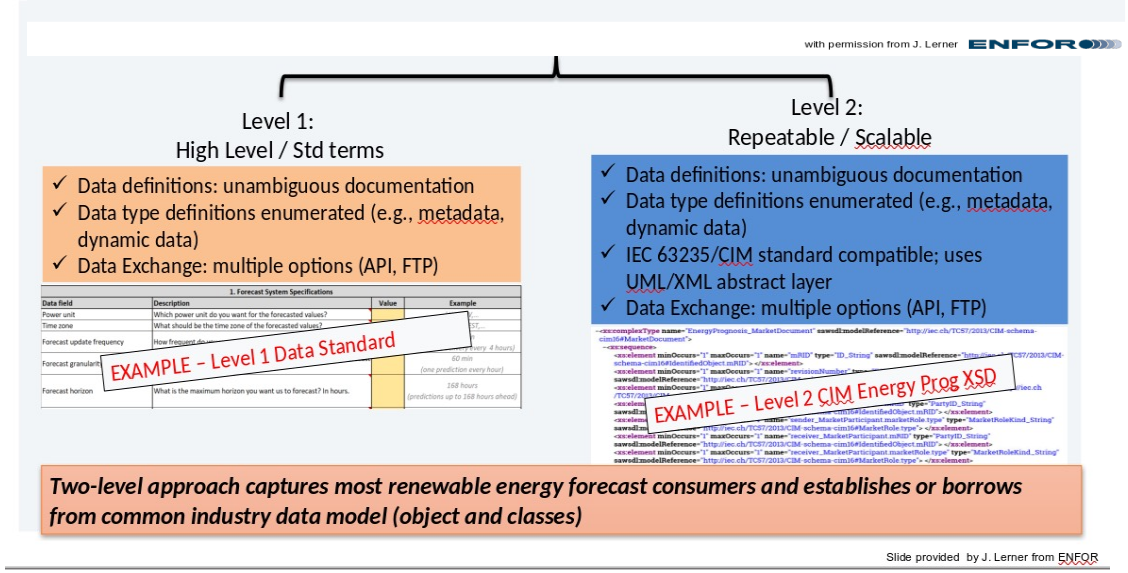
Part 1: Key Points Data Communication

- **Purpose:**
  - Recommendation to standardise timely and reliable data exchange and communication methods to implement and operate optimal forecast solutions for user applications

- **Approach: Logical Data Layers**
  - Master data: Sites and Turbines/Solar units
  - Dynamic data:
  - Forecasts
  - Meta data



- **Approach: Two levels of standards**
  - Level 1: A high-level description of the information and data required to carry out operation and trials of specific forecast solutions
  - Level 2: A detailed specification of format and method for the exchange of data between forecasting provider and forecast user



Part 1: Key Points: SUMMARY

Recommendation:

- Decision support tool for design of customized forecast solution selection process

Remember: An optimal forecast solution needs careful formulation of the solution selection process, consistent with problem size, available expertise and resources

- Data Communication for standard timely and reliable data exchange and communication methods to implement and operate optimal forecast solutions for user applications:

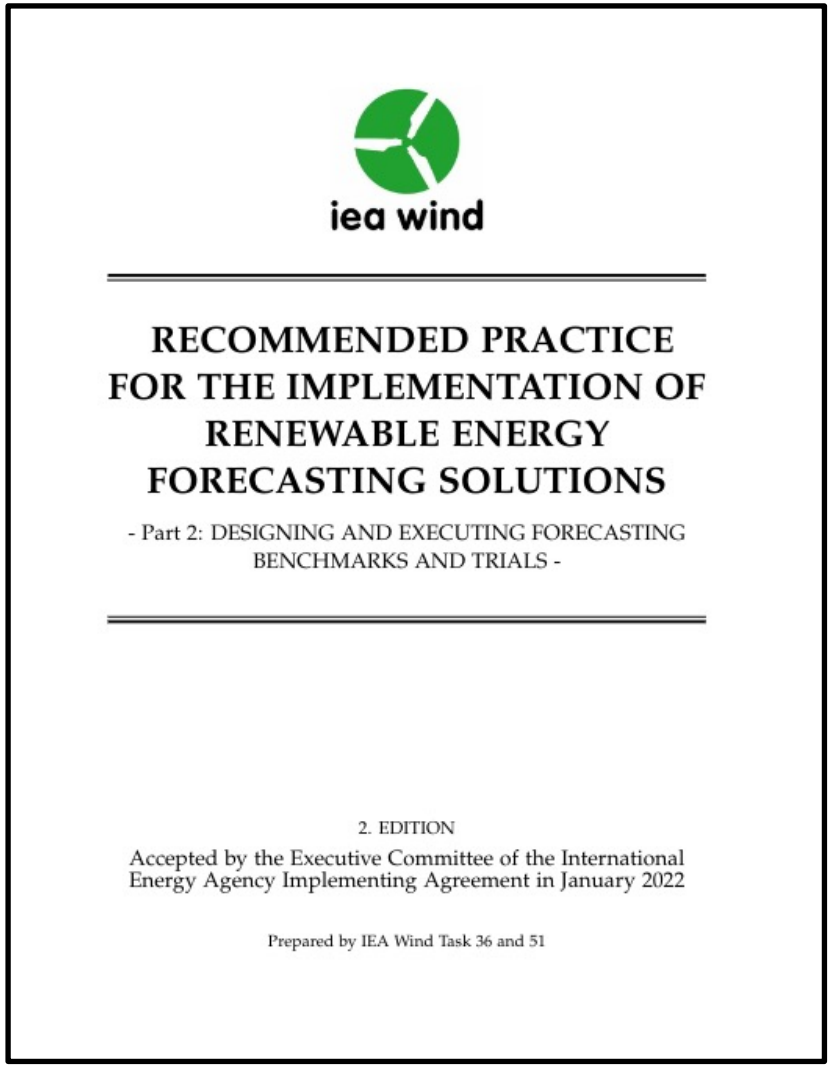
  Level 1: A high-level description of the information and data requirements

  Level 2: A detailed specification of both format and method for the exchange of data

Remember: A optimal forecast solution needs high-quality input data, consistent and reliable in order to produce high-quality forecasts!

Part 2: Conducting a Benchmark or Trial

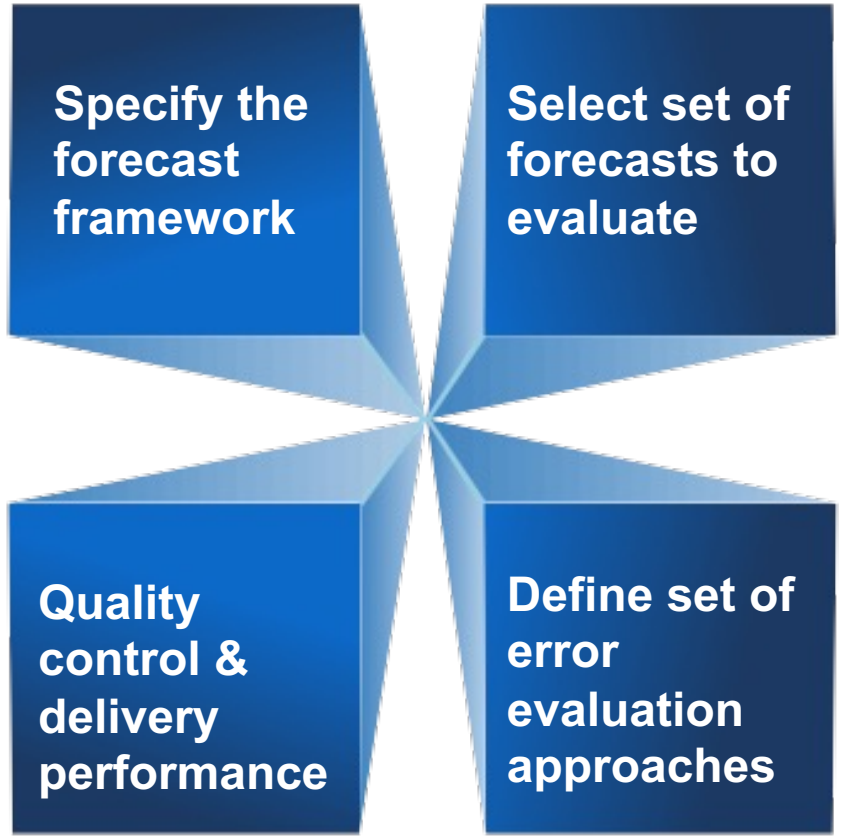
- Presents the three phases of a forecasting benchmark or trial
  - Planning
  - Execution
  - Evaluation
- Discusses the factors and issues that should be considered in each phase
- Provides a list of pitfalls to avoid



Part 2: Key Points

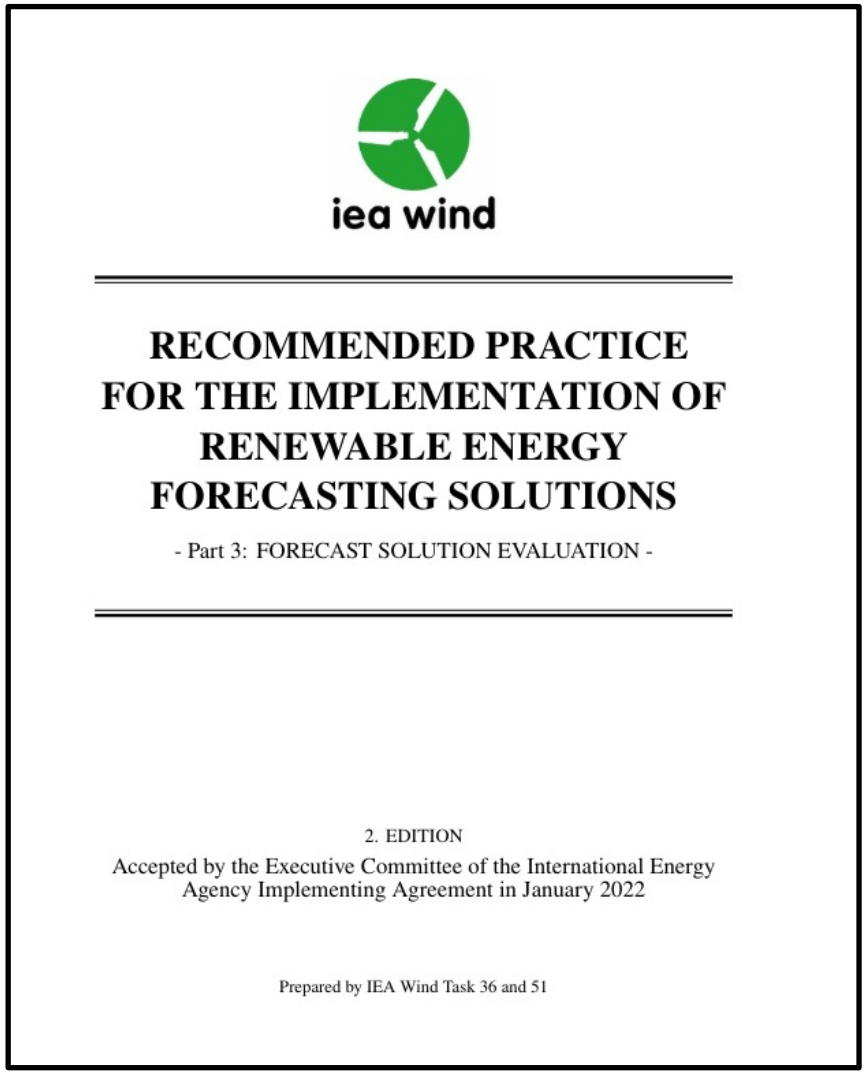
Issue: A benchmark or trial often fails to provide meaningful information to the solution selection process because it is poorly designed or executed and usually requires more resources than planned!

Advice: use the recommended practices guide and/or consult “unbiased” experts if you plan a benchmark or trial.
If it becomes an academic exercise, it’s expensive learning!



Part 3: Evaluation

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



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RECOMMENDED PRACTICE FOR THE IMPLEMENTATION OF RENEWABLE ENERGY FORECASTING SOLUTIONS

- Part 3: FORECAST SOLUTION EVALUATION -

2. EDITION

Accepted by the Executive Committee of the International Energy Agency Implementing Agreement in January 2022

Prepared by IEA Wind Task 36 and 51

Part 3: Key Points

Issues: Many attempts to evaluate the accuracy of alternative forecast solutions yield misleading information to a user's solution selection process because of failures in one or more of the 3 key attribute areas

The most frequent and misunderstood mistake is with respect to "relevance"

- The user employs a set of accuracy metrics that are not appropriate, i.e. "not relevant" for the user's application
- Often accuracy assessments may give a good solution for someone else's problem, but not one's own problem!

Table 15.3 provides a mapping for 8 typical applications and appropriate evaluation

Decision-Making Task	Uncertainty Method(s)	Evaluation Metric	End-User Requirements	Reference
Extreme Events (System Operation and Market bidding)	3a, 3b	Event analysis[3]), Brier scores, Rank/PIT histograms, ROC, Reliability diagram, extended CRPS, Spread-Skill(Error) Relationship	High Sharpness → uncertainty forecasts needs to be spacial and temporal Uncertainty must be model generated → independent of historic data Verification with multiple test required[61,74,89]: • Distribution verification → aims to quantify general fitness to observations • Realizations verification → assess improvement over climate statistics	[58,61, 80,89, 90]
(Ramping) Reserve (System Operation, Market bidding)	2, 3a	Categorial event analysis, Brier Scores, ROC, (C)RPS, Reliability diagram	High Sharpness → low reserve requirements High calibration → Adequate estimation of tails quantiles leads to accurate risk quantification Resolution → dynamic reserve requirement according to power system operating conditions	[20, 34,91]
Unit commitment (UC) and economic dispatch (ED)(System Operator)	2, 3a, 3b	Categorial event analysis, Brier Score, rank histogram, energy score	Hich Calibration → cost savings; Uncertainty adequacy dependent on ensemble method; High skill for event detection → ramping (up and down) detection skill	[90, 92]
Market bidding (Market Player)	1, 2, 3a	Categorial event analysis, Brier Scores, ROC, Reliability diagram, CRPS	Maximize profit, minimise costs (cost-loss evaluation); Low sharpness → low uncertainty (reduced imbalance cost)	[15,37, 50,91, 93]
Virtual power plant operation (Market Player)	2, 3a, 3b	(i) Calibration, sharpness, quantile score and CRPS (ii) Log Score, p-variogram score, energy score, value score	(i) Perfect calibration → perfect reserve reliability estimation; High sharpness → high reserve margin (ii) temporal or spatial dependence structure → proper forecast uncertainty	[50, 56,66, 91]
Predictive grid management (System Operator)	3a	Event analysis, ROC, energy score, reliability diagram	High calibration → reduction of false alarms; High sharpness → low operating costs; low computational requirements	[50, 56,66]
Maintenance scheduling (Wind Farm Operator/ Market Player)	1, 3a	Calibration and sharpness; Cost-loss model under uncertainty, ROC	High Sharpness on event detection for low wind speed periods; High calibration → risk cost minimisation	[56]
Long-term portfolio planning (Market Players, System Operator, Wind Farm Operator)	1, 3a, 3b	Calibration/rank, reliability and sharpness diagrams, RPSS, CRPS, Brier skill score, value score	Calibration → trustworthiness; Reliability → resolution and skill versus climatology; Sharpness → aligns predictive distributions	[19,50, 51,56]

Part 3: Key Points

Work as a team with your vendors!!!!

Recommendations:

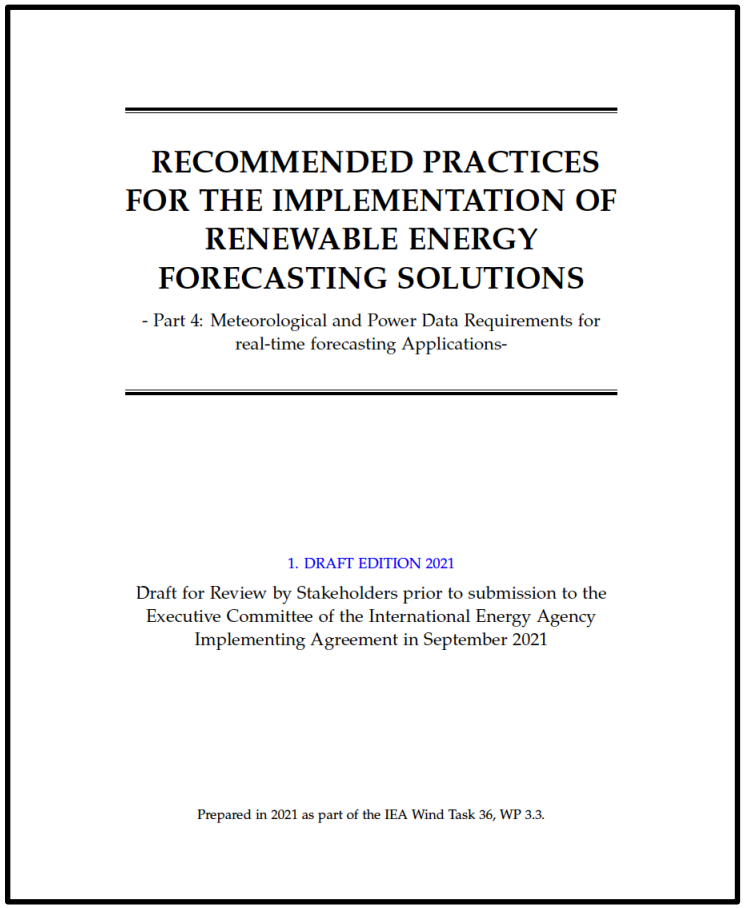
- Put considerable effort into understanding and incentivising the problem solution before employing a forecast provider. Remember: inappropriate metrics lead to wrong solutions!
- Use a set of evaluation criteria in order to capture critical parts of operation and to allow the forecast vendor to improve!

Part 4: Meteorological and Power Data Requirements for Real-time Forecasting Applications
(was added in Version 2)

- **Purpose:**
  - Optimize the selection, deployment, maintenance and quality control of sensors and communication channels to produce the high-quality and timely on-facility meteorological and generation-related data

- **Forecast quality is significantly impacted by on-facility data:**
  - Sensors need to be representative of the ambient atmospheric environment experienced by the generation assets
  - Sensors need to be qualified with respect to the actual operating conditions of the facility (e.g. outages and curtailment)
  - Insufficient forecast quality is often due to embedded bad data elements due to poor quality control
  - Data needs to be provided in a timely and complete manner

Low-quality data leads to low-quality forecasts!



RECOMMENDED PRACTICES FOR THE IMPLEMENTATION OF RENEWABLE ENERGY FORECASTING SOLUTIONS

- Part 4: Meteorological and Power Data Requirements for real-time forecasting Applications-

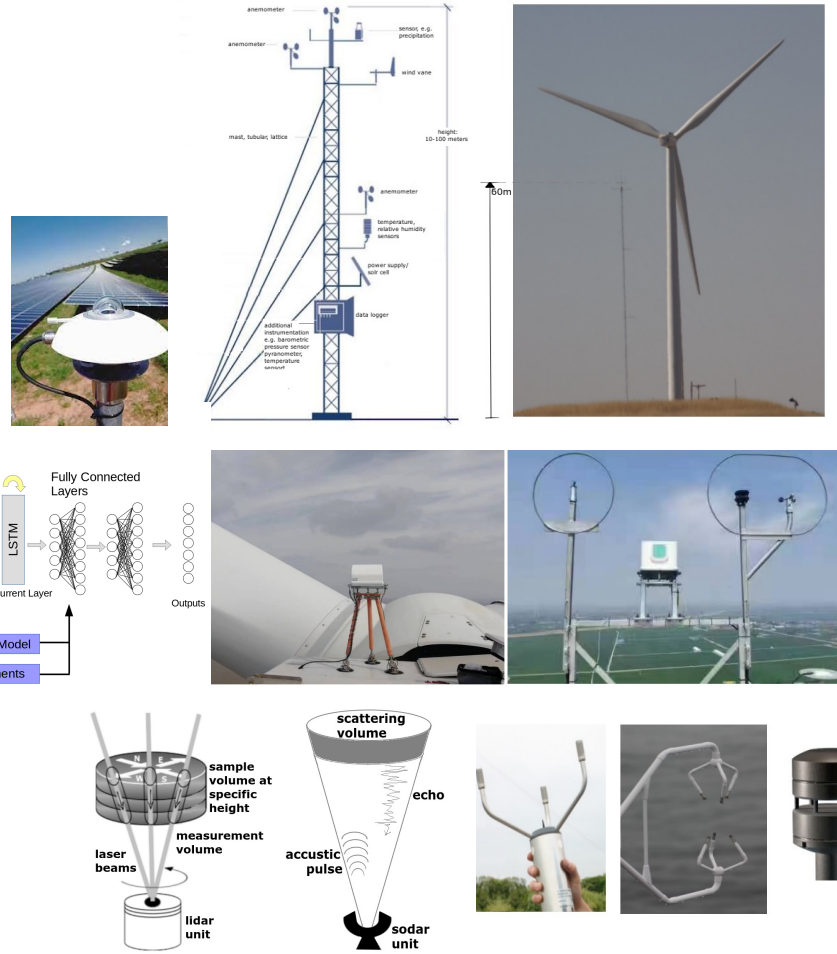
1. DRAFT EDITION 2021

Draft for Review by Stakeholders prior to submission to the Executive Committee of the International Energy Agency Implementing Agreement in September 2021

Prepared in 2021 as part of the IEA Wind Task 36, WP 3.3.

Part 4: Contents and Key Points

1. **Objectives**
   - Data requirement differences – Forecasting vs. other renewable energy (RE) applications
   - Existing applicable standards" RE-based and general meteorological
2. **Meteorological Instrumentation for Real-time Operation**
   - Key attributes of sensor alternatives for wind projects
   - Key attributes of sensor alternatives for solar projects
3. **Power Measurements for Real-time Operation**
4. **Measurement Setup and Calibration**
   - Selection factors for instrumentation
   - Optimal placement of sensors
   - Calibration and Correction Methodologies
   - Maintenance and Inspection schedules
5. **Assessment of Instrumentation Performance**
   - Uncertainty characteristics of measurements
   - Historical and real-time data quality control standards and methods
6. **Summary of Best Practice Recommendations**



Where to Get More Information

RP-related Publications

RP Documents:

- Elsevier Open Access Book
  - November 2022
  - https://www.sciencedirect.com/book/9780443186813/iea-wind-recommended-practice-for-the-implementation-of-renewable-energy-forecasting-solutions
- IEA Wind Task 51 Site
  - iea-wind.org/task51/Publications

2019-2022 Wind Integration Workshops

- Paper in Proceedings
- Presentation

2019 & 2020 ESIG Workshops

- Presentations

YouTube Channel

- Webinar on Recommended Practices

Task 36/51 Information

→ **Task 36 and Task 51 sites**

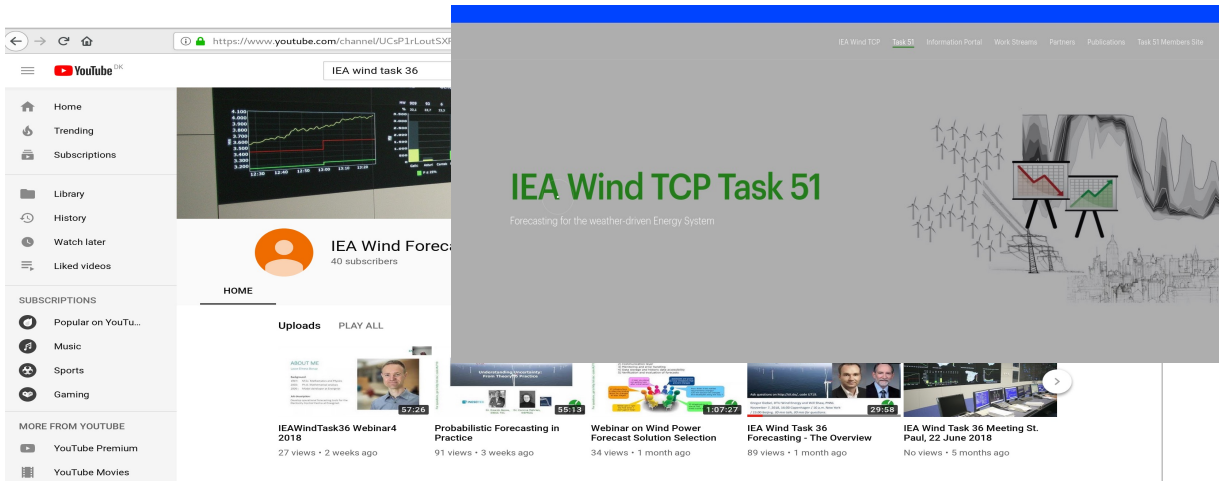
- ieawind.org/task36 & ieawind.org/task51

→ **Research Gate Project**

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

→ **IEA Wind Forecasting YouTube Channel:**

- www.youtube.com/channel/UCsP1rLoutSXP0ECZKicczXg



Thank you for your attention

Questions … ?

Contact us…

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