IEA Wind Task 36 – An Overview

Gregor Giebel, DTU Wind Energy

W. Shaw, H. Frank, C. Möhrlen, C. Draxl, J. Zack, P. Pinson, G. Kariniotakis, R. Bessa

Wind Integration Workshop Online 2020

Task Objectives & Expected Results

Task Objective is to encourage improvements in:
1) weather prediction
2) power conversion
3) use of forecasts

Task Organisation is to encourage international collaboration between:
- → Research organisations and projects
- → Forecast providers
- → Policy Makers
- → End-users and stakeholders

Task Work is divided into 3 work packages:
WP1: Weather Prediction Improvements
WP2: Power and Uncertainty Forecasting
WP3: Optimal Use of Forecasting Solutions

Current Term: 2019-2021 (First term 2016-2018)

05:15 New York // 07:15 Rio de Janeiro // 10:15 London // 15:45 New Delhi // 17:15 Jakarta // 18:15 Peking // 19:15 Tokio

11:15 – 13:00	**SESSION 6A: IEA WIND TASK 36: RAISING THE BAR ON INFORMATION TRANSPARENCY AND RECOMMENDED PRACTICES FOR WIND POWER FORECASTING**
> Session Chair	**Gregor Giebel (DTU Wind Energy, Denmark)**
11:15 – 12:45	**Presentations (18 min. each)**

- **IEA Wind Task 36 Forecasting – An Overview**
  G. Giebel (DTU Wind Energy, Denmark), W. Shaw (PNNL, United States), H. Frank (Deutscher Wetterdienst DWD, Germany), C. Draxl (NREL, United States), J. Zack (UL Services Group, United States), P. Pinson (DTU Elektro, Denmark), C. Möhrlen (WEPROG, Denmark), G. Kariniotakis (Mines ParisTech, France), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-128)
- **Validation of Numerical Model Improvements through Public Data Sets and Code**
  C. Draxl, J. Lee (National Renewable Energy Laboratory – NREL, United States), W. Shaw, L. Berg (Pacific Northwest National Laboratory, United States) (Submission-ID WIW20-124)
- **IEA Wind Task 36: Practical Application Examples from the Recommended Practices for Forecast Solution Selection**
  J. Zack (UL Services Group, United States), C. Möhrlen (WEPROG, Denmark) (Submission-ID WIW20-108)
- **Wind Power Forecasting Data Definitions and Exchange Standards – An Approach for a Recommended Practice Built upon International Standards and an Eye Towards the Future**
  J. Lerner, M. Westenholz (ENFOR, Denmark) (Submission-ID WIW20-126)
- **Insight on Human Decision-making from Probabilistic Forecast Games and Experience: an IEA Wind Task 36 initiative**
  C. Möhrlen (WEPROG, Denmark), N. Fleischhut (Max-Planck Institute for Human Development, Germany), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-98)

12:45 – 13:00	**Discussions**

International Energy Agency History

The IEA was founded in 1974 to help countries co-ordinate a collective response to major disruptions in the supply of oil.

Image source: dpa

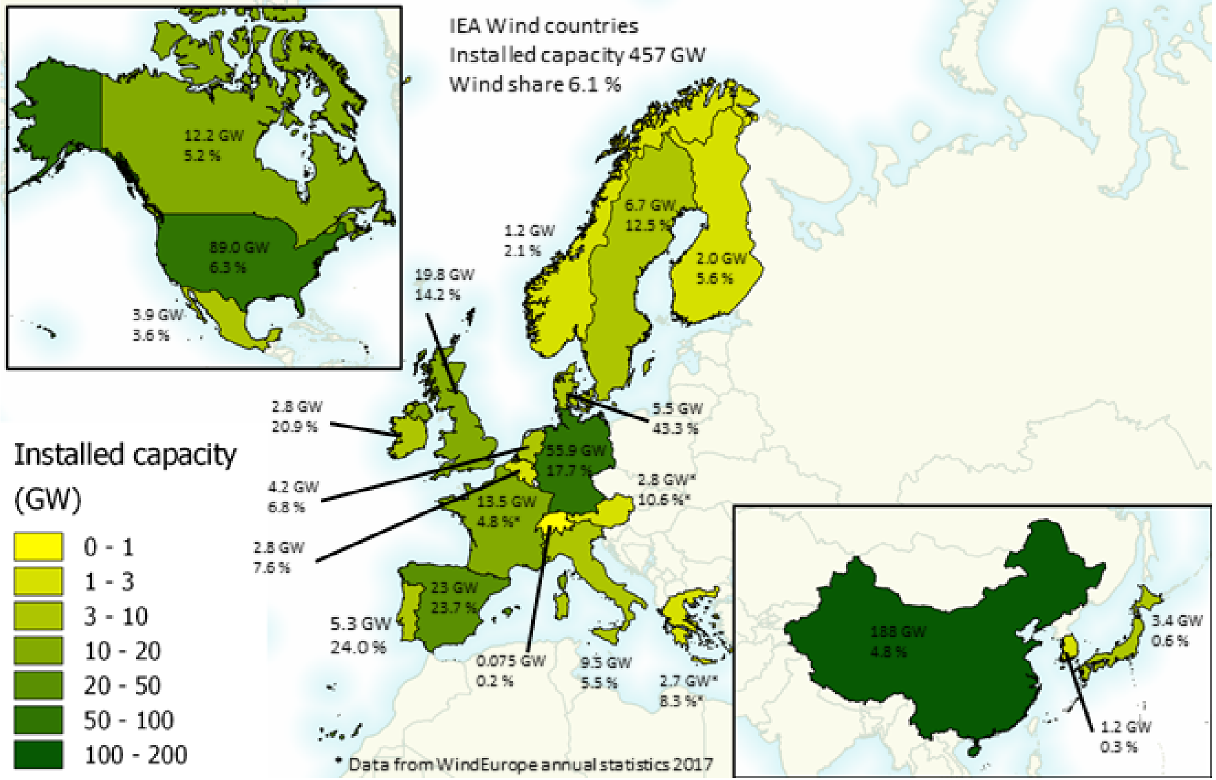
Specific Technology Collaboration Programs:

Bioenergy TCP
Concentrated Solar Power (SolarPACES TCP)
Geothermal TCP
Hydrogen TCP
Hydropower TCP
Ocean Energy Systems (OES TCP)
Photovoltaic Power Systems (PVPS TCP)
Solar Heating and Cooling (SHC TCP)
Wind Energy Systems (Wind TCP)

iea Energy Technology Network

See iea.org!

iea International Energy Agency



Task 36 members:

AT, CN, DE, DK, ES, FI, FR, IE, PT, SE, UK, US

Task 11 Base Technology Exchange
Task 19 Wind Energy in Cold Climates
Task 29 Mexnext III: Analysis of Wind Tunnel Measurements and Improvements of Aerodynamic Models
Task 30 Offshore Code Comparison Collaboration, Continued, with Correlation (OC5)
Task 39 Quiet Wind Turbine Technology
Task 40 Downwind Turbines
Task 41 Distributed Energy
Task 42 Wind Turbine Lifetime Extension
Task 44 Farm Flow Control

See ieawind.org!

Task 31 WAKEBENCH: Benchmarking Wind Farm Flow Models
Task 32 LIDAR: Wind Lidar Systems for Wind Energy Deployment
Task 36 Forecasting for Wind Energy
Task 25 Design and Operation of Power Systems with Large Amounts of Wind Power
Task 27 Small Wind Turbines in High Turbulence Sites
Task 37 Wind Energy Systems Engineering
Task 26 Cost of Wind Energy
Task 28 Social Acceptance of Wind Energy Project
Task 34 Working Together to Resolve the Environmental Effects of Wind Energy (WREN)

Short-term prediction of wind power, quickly explained

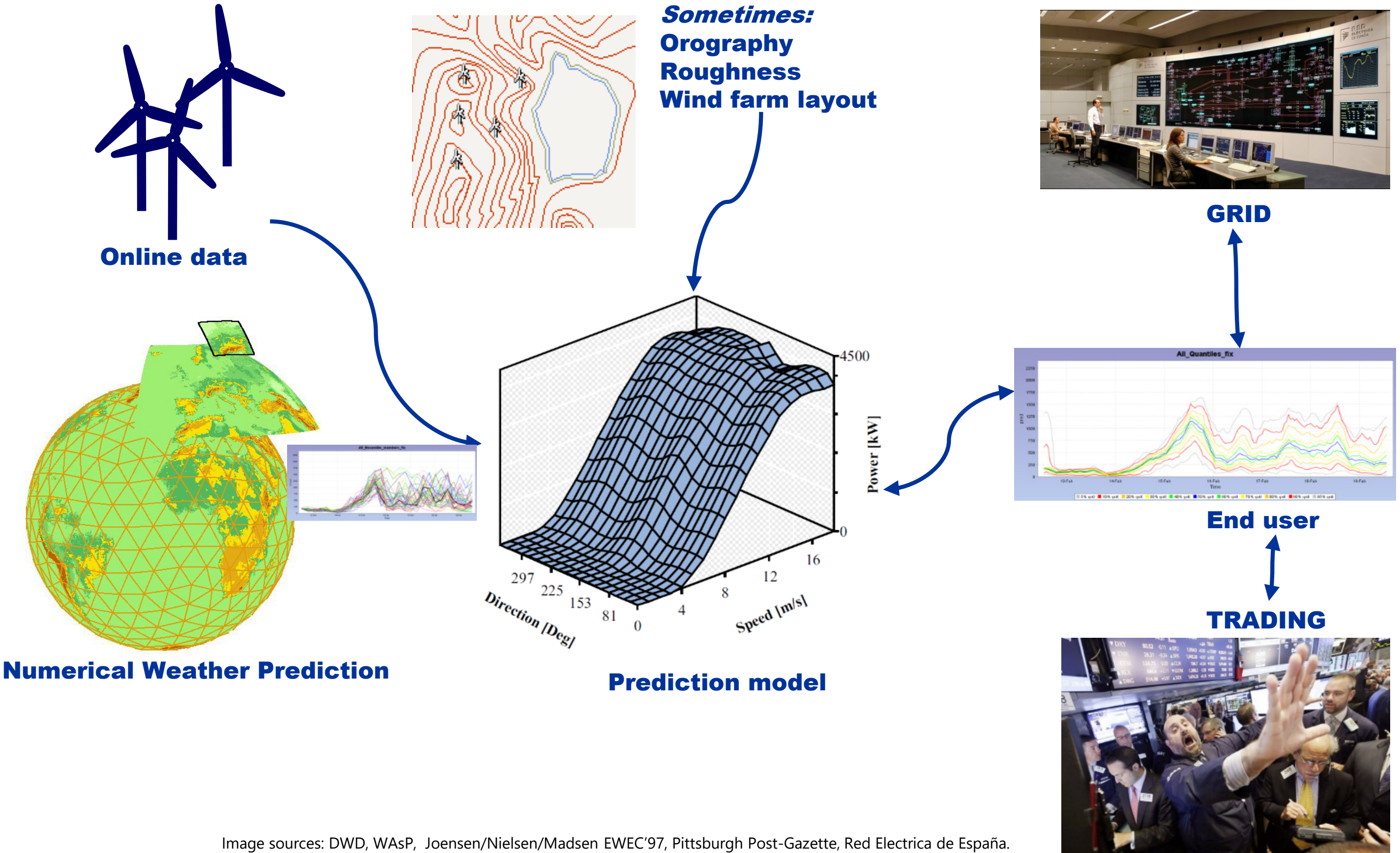
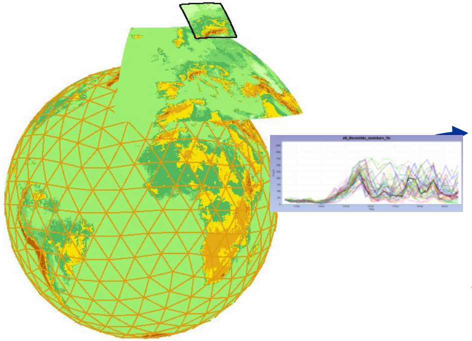
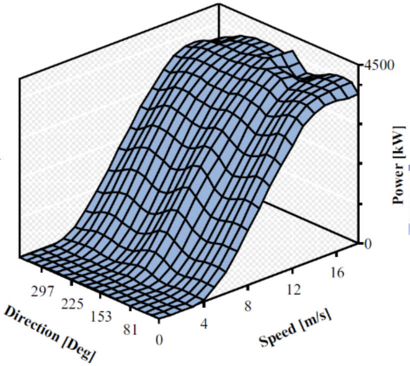


Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Pittsburgh Post-Gazette, Red Electrica de España.



Numerical Weather Prediction

DWD
NOAA
National Weather Service
DMI
ECMWF
Météo France
China Meteorological Administration
Met Office



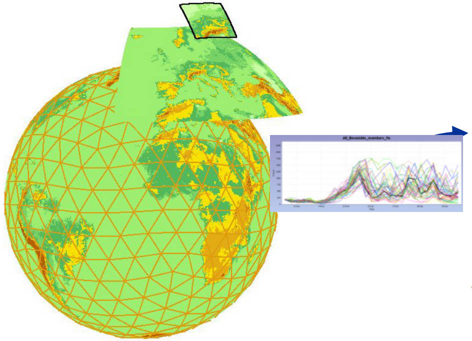
Prediction model

ENFOR Forecasting and Optimization for the Energy Sector
DNV·GL
WEPROG
energy & meteo systems
ConWX
Fraunhofer IWES
EWC European Weather Consult
meteo*swift
NCAR
VAISALA
4cast

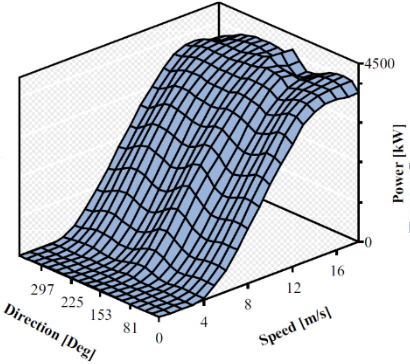
End user

50hertz
ISO new england
ENGIE Green
ercot
amprion
nationalgrid
CNR
California ISO
VATTENFALL
TenneT Taking power further
e·on
ENERGINET/DK
Statoil

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.



Numerical Weather Prediction

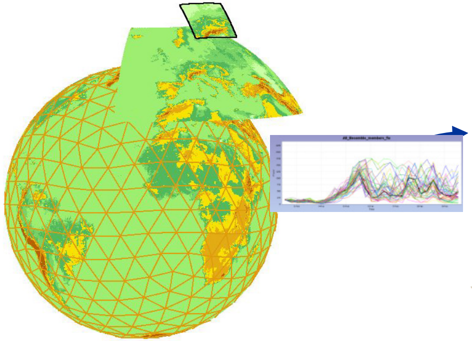


Prediction model

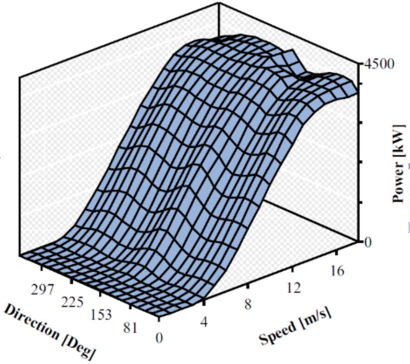
End user

WP1: Coordination Datasets Benchmarks

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.



Numerical Weather Prediction



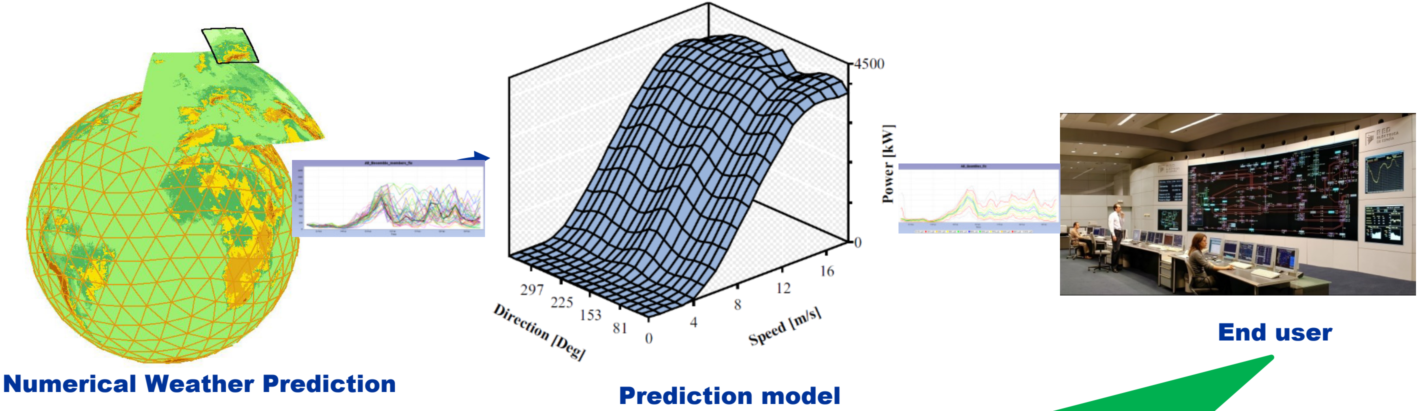
Prediction model

End user

WP2:

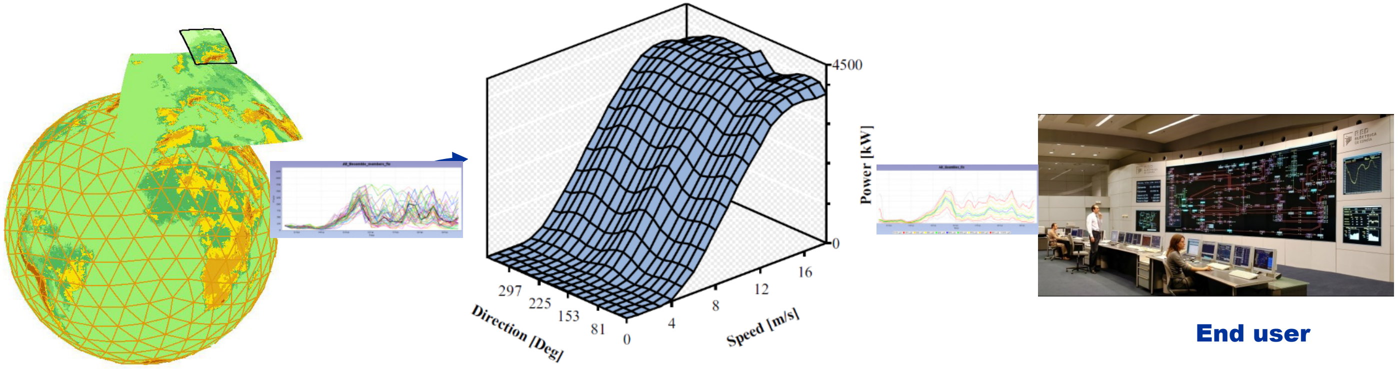
Vendor selection
Evaluation protocol
Benchmarks

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.



WP3: Decision support
Best Practice in Use
Communication

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.



Numerical Weather Prediction

Prediction model

End user

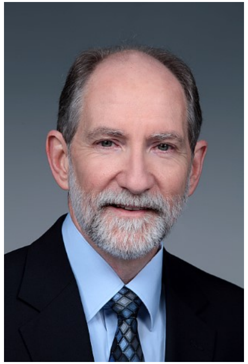
WP1: Coordination Datasets Benchmarks

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.

WP1 Meteorology

Lead:

- Helmut Frank, DWD
- Will Shaw, PNNL



Mission:

To coordinate NWP development for wind speed & power forecasting

WP1 Meteorology

- Task 1.1: Compile list of **available data sets**, especially from tall towers.
- Task 1.2: Creation of annual reports documenting and announcing **field measurement programs** and availability of data.
- Task 1.3: Verify and Validate the improvements through a **common data set** to test model results upon and discuss at IEA Task meetings

WP1 Meteorology Current state

- V&V benchmark defined (US results to be published end of June, benchmark to be published on A2E site)
- Continuously updating the list, and work underway to use the collected data sets for Numerical Weather Prediction

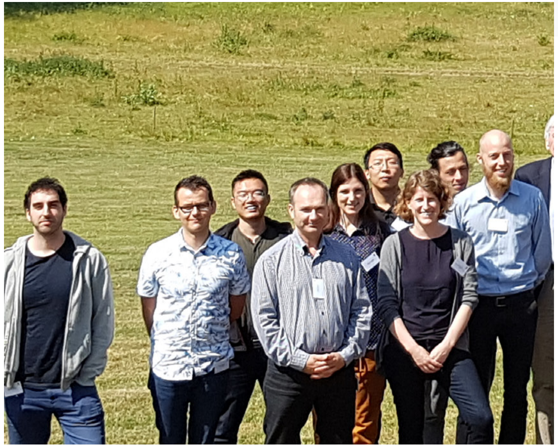
SITE NAME	COORDINATES	ALTITUDE ABOVE MSL	TOWER HEIGHT	URL	CONTACT	DATA POLICY	DATA FORMAT	OBS. PERIOD	OTHER
Cabauw, NL	4.926° E, 51.97° N	-0.7 m	200 m	www.cesar-observatory.nl/index.php	henk.klein.baltink@knmi.nl	Cesar data policy	netCDF	2000-04-01 to previous month	
IJmuiden, NL	3.436° N, 52.848° E	0 m	92 m	www.meteomastijmuiden.nl/en/measurement-campaign/	verhoef@ecn.nl			since 2012	offshore North Sea
Risø, DK	12.088° E, 55.694° N	0 m	125 m	rodeo.dtu.dk/rodeo/ProjectOverview.aspx?&Project=5&Rnd=975820	Allan Vesth	Ask nicely		1995-11-20 -	Data measured since 1958; some months break in 2008.
Østerild, DK	8.88080° E, 57.04888° N	9 m	250 m	rodeo.dtu.dk/rodeo/ProjectOverview.aspx?&Project=17&Rnd=975820	Yoram Eisenberg	Ask nicely		2015-01-28 -	Two 250m masts in 4.3 km distance, both instrumented. Additionally, 7 smaller masts

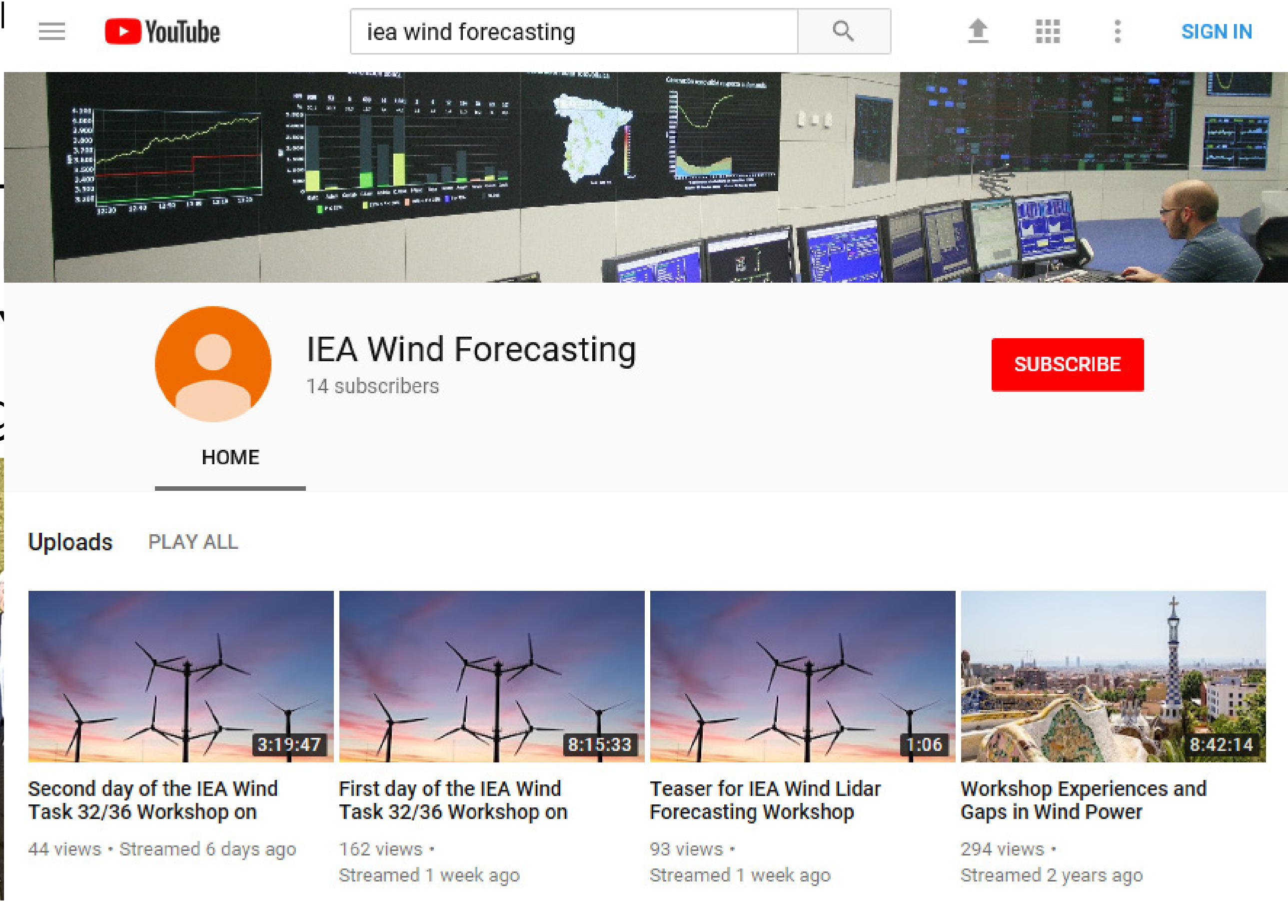
Minute scale forecasting

- How to use Lidars, Radars or SCADA for very short term forecasts
- 30 sec – 15 min.
- Workshop with Task 32 Lidars at Risø 12/13 June 2018.
- Slides available from workshop website.
- Complete workshop on YouTube.
- Summary paper in Energies journal.

Minute scale forecasting

- How to use Lidars, Radar
- 30 sec – 15 min.
- Workshop with Task 32 L
- Slides available from wo
- Complete workshop on
- Summary paper in Energ





Minute scale forecasting

- How to use Lidars, Radars or SCADA for very short t
- 30 sec – 15 min.
- Workshop with Task 32 Lidars at Risø 12/13 June 20
- Slides available from workshop website.
- Complete workshop on YouTube.
- Summary paper in Energies journal.

energies

MDPI

Article

Minute-Scale Forecasting of Wind Power—Results from the Collaborative Workshop of IEA Wind Task 32 and 36

Ines Würth [1,*], Laura Valldecabres [2], Elliot Simon [3], Corinna Möhrlen [4], Bahri Uzunoğlu [5,6], Ciaran Gilbert [7], Gregor Giebel [3], David Schlipf [8] and Anton Kaifel [9]

1 Stuttgart Wind Energy, University of Stuttgart, Allmandring 5b, 70569 Stuttgart, Germany
2 ForWind-University of Oldenburg, Institute of Physics, Küpkersweg 70, 26129 Oldenburg, Germany; laura.valldecabres@forwind.de
3 DTU Wind Energy (Risø Campus), Technical University of Denmark, Frederiksborgvej 399, 4000 Roskilde, Denmark; ellsim@dtu.dk (E.S.); grgi@dtu.dk (G.G.)
4 WEPROG, Willemoesgade 15B, 5610 Assens, Denmark; com@weprog.com
5 Department of Engineering Sciences, Division of Electricity, Uppsala University, The Ångström Laboratory, Box 534, 751 21 Uppsala, Sweden; bahriuzunoglu@computationalrenewables.com
6 Department of Mathematics, Florida State University, Tallahassee, FL 32310, USA
7 Department of Electronic and Electrical Engineering, University of Strathclyde, 204 George St, Glasgow G11XW, UK; ciaran.gilbert@strath.ac.uk
8 Wind Energy Technology Institute, Flensburg University of Applied Sciences, Kanzleistraße 91–93, 24943 Flensburg, Germany; david.schlipf@hs-flensburg.de
9 Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, Meitnerstraße 1, 70563 Stuttgart, Germany; anton.kaifel@zsw-bw.de
* Correspondence: wuerth@ifb.uni-stuttgart.de; Tel.: +49-711-685-68285

Received: 14 December 2018; Accepted: 14 February 2019; Published: 21 February 2019

check for updates

Abstract: The demand for minute-scale forecasts of wind power is continuously increasing with the growing penetration of renewable energy into the power grid, as grid operators need to ensure grid stability in the presence of variable power generation. For this reason, IEA Wind Tasks 32 and 36 together organized a workshop on "Very Short-Term Forecasting of Wind Power" in 2018 to discuss different approaches for the implementation of minute-scale forecasts into the power industry. IEA Wind is an international platform for the research community and industry. Task 32 tries to identify and mitigate barriers to the use of lidars in wind energy applications, while IEA Wind Task 36 focuses on improving the value of wind energy forecasts to the wind energy industry. The workshop identified three applications that need minute-scale forecasts: (1) wind turbine and wind farm control, (2) power grid balancing, (3) energy trading and ancillary services. The forecasting horizons for these applications range from around 1 s for turbine control to 60 min for energy market and grid control applications. The methods that can be applied to generate minute-scale forecasts rely on upstream data from remote sensing devices such as scanning lidars or radars, or are based on point measurements from met masts, turbines or profiling remote sensing devices. Upstream data needs to be propagated with advection models and point measurements can either be used in statistical time series models or assimilated into physical models. All methods have advantages but also shortcomings. The workshop's main conclusions were that there is a need for further investigations into the minute-scale forecasting methods for different use cases, and a cross-disciplinary exchange of different method experts should be established. Additionally, more efforts should be directed towards enhancing quality and reliability of the input measurement data.

Keywords: wind energy; minute-scale forecasting; forecasting horizon; Doppler lidar; Doppler radar; numerical weather prediction models

Energies **2019**, *12*, 712; doi:10.3390/en12040712 www.mdpi.com/journal/energies

Task 1.1 Available Data Sets
Task 1.2 List of Field Campaigns
Task 1.3 Common Test Data
Task 1.4 NWP Forecast Metrics

Task 1.1 Available Data Sets

Meteorological data from tall towers

The following list was compiled by IEA Wind Task 36 Forecasting for Wind Energy.

Another source is **The Tall Tower Dataset** at INDECIS Data portal. This is database of 222 tall towers around the world compiled with a common format (netCDF) and quality controlled. For some towers the latest data is from 2018. See The Tall Tower Dataset Technical Note for a description of the quality control, and a list of the towers in the appendix.

Lead

Helmut Frank
DWD, Deutscher Wetterdienst

SITE NAME	COORDINATES	ALTITUDE ABOVE MSL	TOWER HEIGHT	URL	CONTACT	DATA POLICY	DATA FORMAT	OBS. PERIOD	OTHER
Cabauw, NL	4.926° E, 51.97° N	-0.7 m	200 m	www.cesar-observatory.nl/index.php	marcel.brinkenberg@knmi.nl	Cesar data policy	netCDF	2000-04-01 to previous month	
IJmuiden, NL	3.436° N, 52.848° E	0 m	92 m	www.windopzee.net/en/meteomast-ijmuiden-mmij/	hans.verhoef@tno.nl. Registration for data	Ask here for permission		2012 - 2018	Offshore North Sea
Risø, DK	12.088° E, 55.694° N	0 m	125 m	rodeo.dtu.dk/rodeo/ProjectOverview.aspx?&Project=5&Rnd=975820	Allan Vesth	Ask nicely	xlsx	1995-11-20 -	Data measured since 1958; some months break in 2008.
Østerild, DK	8.88080° E, 57.04888° N	9 m	250 m	rodeo.dtu.dk/rodeo/ProjectOverview.aspx?&Project=179&Rnd=975820	Yoram Eisenberg	Ask nicely	xlsx	2015-01-28 -	Two 250m masts in 4.3 km distance, both instrumented. Additionally, 7 smaller masts up to turbine hub heights.
Taggen, SE	14.519° E, 55.8726° N	0 m	100 m	rodeo.dtu.dk/rodeo/ProjectOverview.aspx?&Project=174&Rnd=758000	Göran Loman			2014-07-29 to 2017-	Offshore. Owned by Vattenfall

IEA WIND TASK 36

iea wind

INFORMATION PORTAL | WORK PACKAGES | PARTNERS | PUBLICATIONS | MEMBER SITE | IEA WIND

WP1 Weather Prediction Improvements | WP2 Benchmarks | WP3 Optimal Use of Forecasting Solutions

f | t | in

Task 1.1 Available Data Sets
Task 1.2 List of Field Campaigns
Task 1.3 Common Test Data
Task 1.4 NWP Forecast Metrics

Task 1.2 List of Field Campaigns

IEA Wind Task 36 Forecasting for Wind Energy
WP 1 Global Coordination in Forecast Model Improvement

January 10, 2020

Helmut Frank (DWD), Irene Schicker (ZAMG), Will Shaw (PNNL)

Lead

Helmut Frank
DWD, Deutscher Wetterdienst

Co-lead

Will Shaw
Pacific North-West National Laboratory

Field measurement programs - Introduction

In IEA Wind Task 36 no experiments are made to compare Numerical Weather Prediction (NWP) models with observations. However, there are work packages trying to foster this comparison. Therefore, we compile a list of experiments which are particularly relevant for wind energy forecasting. We try to give a short description of the experiments and some information on the data.

List of major field experiments in different years

2021/2022:

- AWAKEN (USA)

2020:

- FESSTVaL (Germany)

2019:

- NEWA - Alaiz Experiment (ALEX17) (Spain)

2018:

- NEWA - Perdigão Experiment (Portugal)

2017:

- WFIP 2
- NEWA - Ferry Lidar Experiment (Baltic Sea)
- WIPAF (North Sea, Germany)

2016:

- WFIP2 (USA)
- NEWA - The coastal experiment RUNE (Denmark)

Long list of experiments, linking to a larger description. Includes older experiments with open data.

List of major field experiments in different years

2021/2022:

- AWAKEN (USA)

2020:

- FESSTVaL (Germany)

2019:

- NEWA - Alaiz Experiment (ALEX17) (Spain)

2018:

- NEWA - Perdigão Experiment (Portugal)

2017:

- WFIP 2
- NEWA - Ferry Lidar Experiment (Baltic Sea)
- WIPAF (North Sea, Germany)

2016:

- WFIP2 (USA)
- NEWA - The coastal experiment RUNE (Denmark)
- NEWA - Østerild: Flow over heterogeneous roughness (Denmark)
- NEWA - Hornamossen: flow over forested rolling hills (Sweden)
- NEWA - Kassel forested hill experiment (Germany)
- OBLEX-F1 Offshore Boundary-Layer EXperiment at Fino1 (North Sea)
- WIPAFF (North Sea, Germany)

2015:

- WFIP2 (USA)
- OBLEX-F1 Offshore Boundary-Layer EXperiment at Fino1 (North Sea)
- MATERHORN-Fog 2 (USA)

2014:

- ALNAP (Alps)

2013:

- MATERHORN-Spring (USA)

2012 and older:

- MATERHORN-Fall (USA)
- WFIP (USA)

Major field experiments

AWAKEN

The American Wake Experiment (AWAKEN) is a landmark collaborative international wake observation and validation campaign. Wake interactions are among the least understood and most impactful physical interactions in wind plants today, leading to unexpected power losses and increased operations and maintenance costs. The AWAKEN campaign is designed to gather observational data to address the most pressing science questions about wind turbine wake interactions and aerodynamics and to further understand wake behavior and validate wind plant models. Simultaneously, the AWAKEN campaign will also focus on testing of wind farm control strategies that have been shown to increase wind plant power production. Leveraging the expertise and resources of a large body of National Laboratories, academic institutions, and industry partners will lead to improved wind farm layout with greater power production and improved reliability, ultimately leading to lower wind energy costs.

Objectives

Wind power prediction project list

This list shows a large number of (mostly publically funded) research projects in short-term forecasting of wind power. The list is incomplete, as the emphasis was a) on current projects, and b) on projects collected from the Task participants. Even so, the list contains research projects from the last two decades worth 46 M€, with 32 M€ public funding, though not all of this can be attributed to forecasting (e.g. the IRP Wind or RAVE projects).

If you have additions or comments, please send them to the operating agent, Gregor Giebel (grgi /at/ dtu.dk).

Country	**Project acronym**	**Full title**	**Sponsor**	**Total / Funded budget**	**Start - end date**	**Participants** (IEA Task 36 members in bold)
DE	e-TWINS	Verbundvorhaben: e-TWINS ' Ganzheitliche digitale Zwillingstechnologie für das Energiesystem	BMWi (Bundesministerium für Wirtschaft und Energie)	1.96 M€ / 1.96 M€	Jan 2020 - Dec 2022	TU München Windenergie, Hochschule München, **ZSW**, Mesh Engineering
EU	Smart4RES	Next Generation Modelling and Forecasting of Variable Renewable Generation for Large-scale Integration in Energy Systems and Markets	EU Horizon2020	4 M€ / 4 M€	1 Nov 2019 - 30 Apr 2023	**Armines, DTU, INESC TEC, EDP, Meteo-France, emsys, DNV GL,** Whiffle, Dowel, ICCS, HEDNO, DLR
EU	EoCoE II	Energy Oriented Center of Excellence : toward exascale for energy	EU Horizon2020	9.2M€	1.1.2019-31.12.2021	18 teams in 7 countries including **Fraunhofer IEE**
DK	[link]	IEA Wind Task 36 Phase II Danish Consortium	EUDP (national Danish funding)	500k€ / 300k€	1 Jan 2019 - 31 Dec 2021	**DTU, ConWX, ENFOR, DNV, WEPROG, Ea Energianalyse, Energinet**

Wind power prediction project list

This list shows a large number of (mostly publically funded) research projects in short-term forecasting of wind power. The list is incomplete, as the emphasis was a) on current projects, and b) on projects collected from the Task participants. Even so, the list contains research projects from the last two decades worth 46 M€, with 32 M€ public funding, though not all of this can be attributed to forecasting (e.g. the IRP Wind or RAVE projects).

If you have additions or comments, please send them to the operating agent, Gregor Giebel (grgi /at/ dtu.dk).

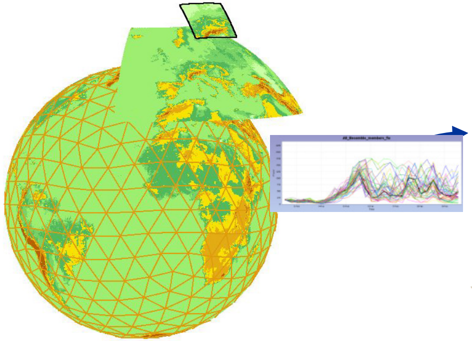
Country	Project acronym	Full title	Sponsor	Total / Funded budget	Start - end date	Participants (IEA Task 36 members in bold)
DE	e-TWINS	Verbundvorhaben: e-TWINS ' Ganzheitliche digitale Zwillingstechnologie für das Energiesystem	BMWi (Bundesministerium für Wirtschaft und Energie)	1.96 M€ / 1.96 M€	Jan 2020 - Dec 2022	TU München Windenergie, Hochschule München, **ZSW**, Mesh Engineering
EU	Smart4RES	Next Generation Modelling and Forecasting of Variable Renewable Generation for Large-scale Integration in Energy Systems and Markets	EU Horizon2020	4 M€ / 4 M€	1 Nov 2019 - 30 Apr 2023	**Armines, DTU, INESC TEC, EDP, Meteo-France, emsys, DNV GL,** Whiffle, Dowel, ICCS, HEDNO, DLR
EU	EoCoE II	Energy Oriented Center of Excellence : toward exascale for energy	EU Horizon2020	9.2M€	1.1.2019-31.12.2021	18 teams in 7 countries including **Fraunhofer IEE**
DK	[link]	IEA Wind Task 36 Phase II Danish Consortium	EUDP (national Danish funding)	500k€ / 300k€	1 Jan 2019 - 31 Dec 2021	**DTU, ConWX, ENFOR, DNV, WEPROG, Ea Energianalyse, Energinet**
		impact on the Danish power system	EUDP)			**Vattenfall**
NO	NowWind	Nowcasting for wind energy production - an integrated modelling approach	The Research Council of Norway (ENERGIX)	12 MNOK / 6.3 MNOK (1.3 / 0.7 M€)	2016 - 2019	**MET Norway, Windsim AS, Vestas Wind Systems AS,** TrønderEnergi AS, **Kjeller Vindteknikk** AS
FR	FOREWER	**Modélisation, prévision et évaluation des risques pour la production d'énergie éolienne**	Agence Nationale de la Recherche (French)	2160 k€ / 481 k€	1 Oct 2014 - 31 Mar 2019	Université Paris 7, **ENGIE Green**, Ecole Polytechnique, EDF, RTE, CNRS
FR	meteo*swift	Development of a short-term wind power forecasting tool based on adaptive multi-agent systems and ensemble weather forecasts	FEDER EU funding & Occitania French region	~1 M€ / ~500 k€	Mar 2016 - Mar 2018	**meteo*swift,** National Weather Research Center (part of Météo-France), Toulouse Computer Science Research Institute
DK	[link]	IEA Wind Task 36 Forecasting Danish Consortium	EUDP (nationally Danish)	2.72 MDKK / 1.83 MDKK	Jan 2016 - Dec 2018	**DTU Wind Energy, DTU Elektro, DTU Compute, DMI, ENFOR, DNV GL, WEPROG, Vestas, Energinet.dk**
US		IEA Task on Development & Use of Probabilistic	Department of Energy USA	$22,732	Sep 2016 - Sep 2017	**NREL**
US	WFIP 2 (alternate link)	Second Wind Forecast Improvement Project	U.S. Department of Energy	$17M USD / $17M USD	1 Oct 2015 - 30 Sep 2018	**Vaisala, NOAA/ESRL, NOAA/ARL, NOAA/NWS,** Argonne National Laboratory, Lawrence Livermore National Laboratory, **NREL, PNNL**
EU	EoCoE	Energy oriented Centre of Excellence	EU Horizon2020	~5.5 M€ / ~1.4 M€	Oct 2015 – Sep 2018	21 teams in 8 countries, lead by Maison de la Simulation, including **Fraunhofer IWES**
EU	IRP Wind	Integrated EU R&D efforts on wind energy	EU 7th Framework Programme (Project ID: 609795)	~ 10 M€ / ~10 M€	Mar 2014 – Feb 2018	24 European teams (participants of the European Energy Research Alliance (EERA) Joint Programme on Wind Energy) lead by **DTU Wind Energy**
DE	PriME	Innovative probabilistic methods for energy system technology	German Federal Ministry of Education and Research (BMBF)	~1 M€ / ~1 M€	Jan 2015 – Dec 2017	University Kassel, **FH IWES**, EnerginetDK, Netze BW
FR/DK	HD-RESforecast	High-dimensional dynamical models for improving renewable energy forecasting at distributed locations	EDF	116 k€ / 65 k€	Nov 2015 -	**DTU Elektro**, EDF
DE	VORKAST	Optimisation of design and operational management for hybrid power plants and energy storage technologies by means of wind and PV power nowcasting (Optimierung der Auslegung und Betriebsführung	Federal Ministry for Economics and Technology	1 M€ / 1 M€	1 Sep 2014 – 31 Oct 2017	ZSW - Center for Solar Energy and Hydrogen Research Baden-Württemberg (Project lead) SWE – Stuttgart Wind Energy @ Institute of Aircraft Design, University of Stuttgart
DE	SMART GRID SOLAR		Bavarian ministry for economy, EU infrastructure fund "Investments for the future"	10 M€ / 6.3 M€	2012 - 2018	Bavarian Center for Applied Energy Research (ZAE), 3 Fraunhofer institutes, 9 other partners and **WEPROG**
PT	P1	Renewable Energy Dispatch Tools	China Electric Power Research Institute (CEPRI); State Grid Corporation of China (SGCC)	2 M€ / -	1 Jul 2013 - 31 Dec 2016	R&D NESTER (PT), **REN** (PT), **CEPRI** (CN)
DK	X-WiWa	Extreme winds and waves for offshore turbines	ForskEL (PSO)	5.96 MDKK / 5.4 MDKK	1 Jun 2013 - 2017	**DTU Wind Energy**, DHI, **Uni Research,** Bergen University
DE	EWeLiNE	Erstellung innovativer Wetter- und Leistungsprognosemodelle für die Netzintegration wetterabhängiger Energieträger	Bundesministerium für Wirtschaft und Energie	7.06 M€ / 6.5 M€	Dec 2012 - Feb 2017	**Fraunhofer IWES, DWD,** Amprion, TenneT, 50Hertz
DE	PerduS	Photovoltaikertragsreduktion durch Saharastaub	BMWi (Bundesministerium für Wirtschaft und Energie)	962 k€ / 962 k€	Nov 2012 - Feb 2017	**Deutscher Wetterdienst,** KIT, meteocontrol
EU	SafeWind	Multi-scale data assimilation, advanced wind modeling and forecasting with emphasis to extreme weather situations for a integration	EU 7th Framework Programme (FP7-ENERGY, Project ID: 213740)	5.6 M€ / 3.98 M€	1 Sep 2008 - 31 Aug 2012	**Armines, DTU, Risø, Uni Oldenburg, ENFOR, Overspeed, CENER, Energinet.dk** and 13 other partners
DK	DEWEPS	Development and Evaluation of a new wind profile theory with an Ensemble Prediction System	Danish PSO Fund	480 k€ / 180 k€	1 Apr 2009 - 31 Dec 2011	**WEPROG**
EU	ANEMOS.plus	**Advanced Tools for the Management of Electricity Grids with Large-Scale Wind Generation**	EU 6th Framework Programme (Project ID: 38692)	5.7 M€ / 2.6 M€	1 Jan 2008 - 30 Jun 2011	**Armines, DTU, Risø, ENFOR, Overspeed, CENER, INESC,** and 14 other partners
DE	RAVE	Research at Alpha Ventus - Grid Integration of offshore wind farms	**BMU, German ministry for the Environment**	5 M€ (60-80% funded)	2008 - 2011	**Fraunhofer IWES, Forwind - University Oldenburg, Deutscher Wetterdienst, WEPROG**
DK	HREnsembleHR	**High-resolution Ensemble for Horns Reef**	**Danish PSO Fund (Contract No. 2006-1-6387)**	700 k€ / 400 k€	1 Apr 2006 - 31 Dec 2009	**WEPROG, DTU IMM, DTU Risø, Fraunhofer IWES, DONG Energy, Vattenfall**
EU	POW'WOW	Prediction of Waves, Wakes and Offshore Wind	EU 6th Framework Programme (Project ID 19898)	1.05 M€ / 1.05 M€	1 Oct 2005 - 30 Mar 2009	**Risø, DTU, Armines, CENER, Uni Oldenburg, Fraunhofer IWES**, and 8 other partners including UFPE (BR)
EU	ANEMOS	Development of a next generation wind resource forecasting system for the large-scale integration of onshore and offshore wind farms	EU 5th Framework Programme (Project ID: ENK5-CT-2002-00665)	4.3 M€ / 2.5 M€	1 Oct 2002 - 30 Sep 2006	**Armines, DTU, Uni Oldenburg, CENER, IASA,** and 16 others from TSOs to meteorologists

05:15 New York // 07:15 Rio de Janeiro // 10:15 London // 15:45 New Delhi // 17:15 Jakarta // 18:15 Peking // 19:15 Tokio

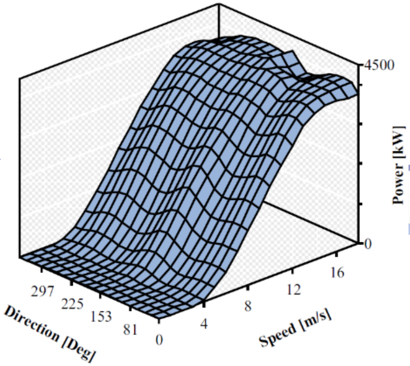
11:15 – 13:00	**SESSION 6A: IEA WIND TASK 36: RAISING THE BAR ON INFORMATION TRANSPARENCY AND RECOMMENDED PRACTICES FOR WIND POWER FORECASTING**
> Session Chair	Gregor Giebel (DTU Wind Energy, Denmark)
11:15 – 12:45	**Presentations (18 min. each)**

- **IEA Wind Task 36 Forecasting – An Overview**
  G. Giebel (DTU Wind Energy, Denmark), W. Shaw (PNNL, United States), H. Frank (Deutscher Wetterdienst DWD, Germany), C. Draxl (NREL, United States), J. Zack (UL Services Group, United States), P. Pinson (DTU Elektro, Denmark), C. Möhrlen (WEPROG, Denmark), G. Kariniotakis (Mines ParisTech, France), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-128)
- **Validation of Numerical Model Improvements through Public Data Sets and Code**
  C. Draxl, J. Lee (National Renewable Energy Laboratory – NREL, United States), W. Shaw, L. Berg (Pacific Northwest National Laboratory, United States) (Submission-ID WIW20-124)
- **IEA Wind Task 36: Practical Application Examples from the Recommended Practices for Forecast Solution Selection**
  J. Zack (UL Services Group, United States), C. Möhrlen (WEPROG, Denmark) (Submission-ID WIW20-108)
- **Wind Power Forecasting Data Definitions and Exchange Standards – An Approach for a Recommended Practice Built upon International Standards and an Eye Towards the Future**
  J. Lerner, M. Westenholz (ENFOR, Denmark) (Submission-ID WIW20-126)
- **Insight on Human Decision-making from Probabilistic Forecast Games and Experience: an IEA Wind Task 36 initiative**
  C. Möhrlen (WEPROG, Denmark), N. Fleischhut (Max-Planck Institute for Human Development, Germany), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-98)

12:45 – 13:00	**Discussions**



Numerical Weather Prediction



Prediction model

End user

WP2:

Vendor selection
Evaluation protocol
Benchmarks

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.

WP2 Benchmarks

Lead:
Caroline Draxl, NREL
John Zack, UL
Pierre Pinson, DTU Elektro



Task 2.1 Forecast Solution Selection
Task 2.2 Uncertainty
Task 2.3 Test Cases
Task 2.4 Standardisation

Task 2.3 Test Cases

Set-up and dissemination of benchmark test cases and data sets.

-

  Aim: Set-up and dissemination of benchmarks.
- **Partners:** DTU Elektro, DTU Wind Energy, EDF, INESC TEC, Smartwatt, Prewind, PNNL.

NAME	TYPE OF DATA	AREA	PERIOD	TEMPORAL RESOLUTION
RE-Europe	Simulated aggregated generation and +1 to +91 hour forecasts for 1494 European regions based on ECMWF and COSMO analysis and ECMWF forecast data	Europe	2012-2014	1 hour
NREL WIND Toolkit	Simulated generation and 1, 4, 6, and 24-hour wind and power forecasts for 126000 US sites based on WRF	US	2007-2013	5 min
NREL Western and Eastern Wind Integration data sets	Simulated generation for 1326 (Eastern) + 32043 (Western) US sites based on MASS and WRF. For Eastern data set also 4 hour, 6 hour and day ahead forecasts	US	2004-2006	10 min
GEFCom 2012	Observed generation and +1 to +48 hour ECMWF wind forecasts for 7 wind farms	unknown	2009-2012	1 hour
GEFCom 2014	Observed generation and +1 to +48 hour ECMWF wind forecasts for 7 wind farms	unknown	2009-2012	1 hour
AEMO	Generation data from various Australian wind farms	Australia	2005-	5 min
La Haute Borne wind farm data	Many SCADA data from the 4 turbines of the La Haute Borne wind farm, ENGIE's first open data wind farm.	Southwest of Nancy, France	2009-	10 min

Co-lead

Pierre Pinson
Professor
DTU Electrical Engineering
+45 45 25 35 41

Additional information:

RE-Europe:
Full data set can be downloaded as zip-file. Generation signals and forecasts and meta data on location and aggregation are stored in csv-files. Additional to wind power data the data set includes solar generation and power load data. More information can be found on https://zenodo.org/record/35177#.WqmNAzclFmB. Data policy: Creative Commons Attribution-NonCommercial 4.0.

NREL WIND Toolkit:
Information and download links can be found on https://www.nrel.gov/grid/wind-integration-data.html. Data can be downloaded via the NREL Wind Prospector

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

iea wind

EXPERT GROUP REPORT

ON

RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 1: FORECAST SOLUTION SELECTION PROCESS

1. EDITION 2019

Submitted to the
Executive Committee of the
International Energy Agency Implementing Agreement
on 13th August 2019

- Part 1: Selection of an Optimal Forecast Solution

iea wind

EXPERT GROUP REPORT
ON
IEA RECOMMENDED PRACTICE FOR
SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 2: DESIGNING AND EXECUTING FORECASTING BENCHMARKS AND TRIALS

1. EDITION 2019

Submitted to the Executive Committee of the International Energy Agency Implementing Agreement
on 1st August 2019

- Part 2: Design and Execution of Benchmarks and Trials

iea wind

EXPERT GROUP REPORT

ON

RECOMMENDED PRACTICES FOR SELECTING RENEWABLE POWER FORECASTING SOLUTIONS

Part 3: Evaluation of Forecasts and Forecast Solutions

1. EDITION 2019

Submitted to the
Executive Committee of the
International Energy Agency Implementing Agreement
on 13th August 2019

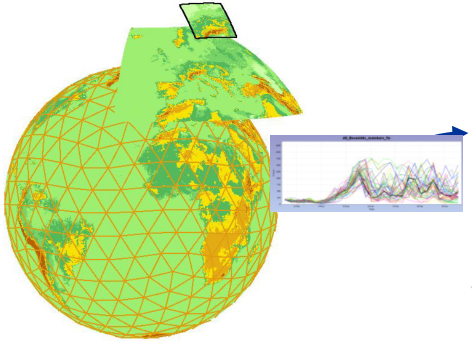
- Part 3: Evaluation of Forecasts and Forecast Solutions

05:15 New York // 07:15 Rio de Janeiro // 10:15 London // 15:45 New Delhi // 17:15 Jakarta // 18:15 Peking // 19:15 Tokio

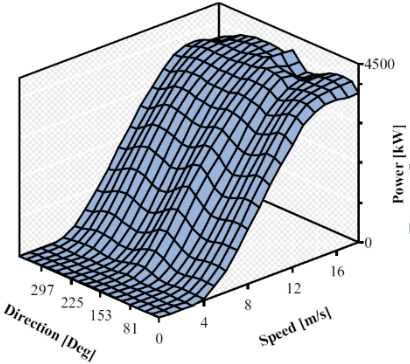
11:15 – 13:00	SESSION 6A: IEA WIND TASK 36: RAISING THE BAR ON INFORMATION TRANSPARENCY AND RECOMMENDED PRACTICES FOR WIND POWER FORECASTING
> Session Chair	Gregor Giebel (DTU Wind Energy, Denmark)
11:15 – 12:45	**Presentations (18 min. each)**

- IEA Wind Task 36 Forecasting – An Overview
  G. Giebel (DTU Wind Energy, Denmark), W. Shaw (PNNL, United States), H. Frank (Deutscher Wetterdienst DWD, Germany), C. Draxl (NREL, United States), J. Zack (UL Services Group, United States), P. Pinson (DTU Elektro, Denmark), C. Möhrlen (WEPROG, Denmark), G. Kariniotakis (Mines ParisTech, France), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-128)
- Validation of Numerical Model Improvements through Public Data Sets and Code
  C. Draxl, J. Lee (National Renewable Energy Laboratory – NREL, United States), W. Shaw, L. Berg (Pacific Northwest National Laboratory, United States) (Submission-ID WIW20-124)
- IEA Wind Task 36: Practical Application Examples from the Recommended Practices for Forecast Solution Selection
  J. Zack (UL Services Group, United States), C. Möhrlen (WEPROG, Denmark) (Submission-ID WIW20-108)
- Wind Power Forecasting Data Definitions and Exchange Standards – An Approach for a Recommended Practice Built upon International Standards and an Eye Towards the Future
  J. Lerner, M. Westenholz (ENFOR, Denmark) (Submission-ID WIW20-126)
- Insight on Human Decision-making from Probabilistic Forecast Games and Experience: an IEA Wind Task 36 initiative
  C. Möhrlen (WEPROG, Denmark), N. Fleischhut (Max-Planck Institute for Human Development, Germany), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-98)

12:45 – 13:00	**Discussions**



Numerical Weather Prediction



Prediction model

End user

WP3:

- Decision support
- Scenarios
- Best Practice in Use
- Communication

Image sources: DWD, WAsP, Joensen/Nielsen/Madsen EWEC'97, Red Electrica de España.

WP3 Advanced Usage

Lead:
Corinna Möhrlen, WEPROG
Ricardo Bessa, INESC TEC
George Kariniotakis, Mines ParisTech

15th Int. Workshop on Large-Scale Integration of Wind Power into Power Systems, Vienna, Nov. 2016

Use of Forecast Uncertainties in the Power Sector: State-of-the–Art of Business Practices

C. Möhrlen*, R. J. Bessa†, M. Barthod‡, G. Goretti§ and M. Siefert¶
*WEPROG ApS, Assens, Denmark, Email: com@weprog.com
†INESC TEC, Porto, Portugal, Email: ricardo.j.bessa@inesctec.pt
‡meteo*swift, Toulouse, France, Email: morgane.barthod@meteoswift.com
§Dublin Institute of Technology, Ireland, Email: gianni.goretti@mydit.ie
¶Fraunhofer IWES, Kassel, Germany, Email: malte.siefert@iwes.fraunhofer.de

***Abstract*—The work we present is an investigation on the state-of-the-art use of forecast uncertainties in the business practices of actors in the power systems sector that is part of the "IEA Wind Task 36: Wind Power Forecasting". The purpose of this task is to get an overview of the current use and application of probabilistic forecasts by actors in the power industry and investigate how they estimate and deal with uncertainties. The authors with expertise in probabilistic forecasting have been gathering information from the industry in order to identify the areas, where progress is needed and where it is difficult to achieve further progress. For this purpose, interview questions were compiled for different branches in the power industry and interviews carried out all around the world in the first six months of 2016. At this stage, we present and discuss results from this first round of interviews and draw preliminary conclusions outlining gaps in current forecasting methodologies and their use in the industry. At the end we provide some recommendations for next steps and further development with the objective to formulate guidelines for the use of uncertainty forecasts in the power market at a later stage.**

I. Introduction

The relevance of forecast uncertainties for wind power and other renewable energies grows as the penetration of these sources in the energy mix increases. Once a certain level of penetration is reached, ignoring the reliability of forecasts not only becomes expensive in terms of reserve roughly goes with wind speed to the power of three, and small errors and uncertainties are thus amplified and have an even higher impact compared to wind speed uncertainties. Weather development associated with fronts moving over large areas where wind is increasing rapidly over a short time are the most critical situations for a balance responsible party or a transmission system operator (TSO): it is under these circumstances that a deterministic forecast may be strongly incorrect and suppress steep ramping that can cause system security issues as well as large imbalances. Translated in the market, it means that there can be a sudden lack of power during a down-ramping event or too little flexible power that can be down-regulated fast and efficiently, which then results in curtailment. As long as the penetration level of wind is below 20% of generation, such uncertainty can usually be dealt with with a reasonable amount of reserves. As penetration increases, or in the case of island grids or badly interconnected grids, reserves and ancillary services grow above a desirable level.

In order to get an understanding of the current state of use of uncertainty forecasts and to find the gaps in the understanding of uncertainties and the associated forecasting tools and methods, we have been carrying out a study with a combination of questionnaires and interviews, which will

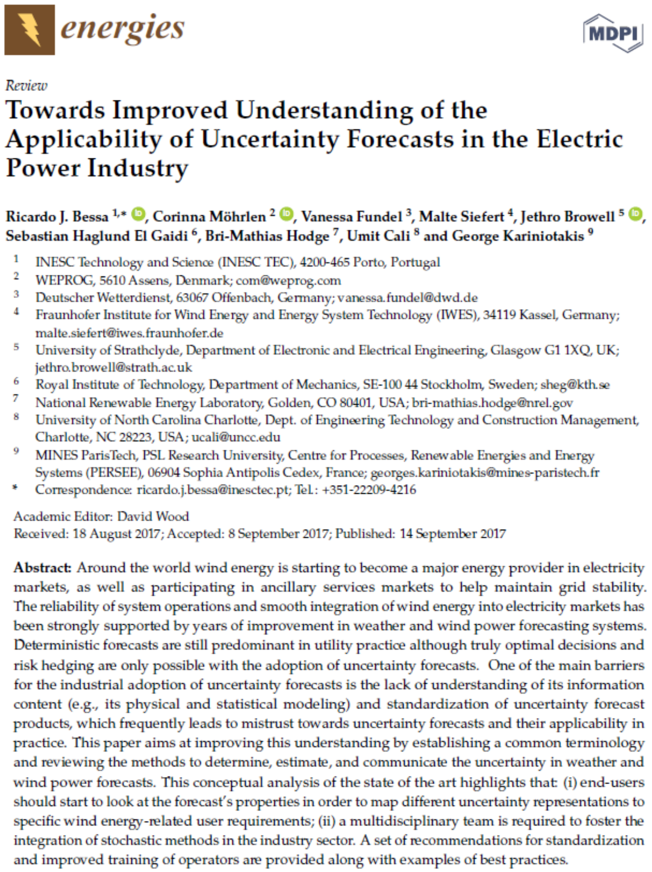
Use of probabilistic forecasting

Open Access journal paper

48 pages on the use of uncertainty forecasts in the power industry

Definition – Methods – Communication of Uncertainty – End User Cases – Pitfalls - Recommendations

Source: http://www.mdpi.com/1996-1073/10/9/1402/


energies

MDPI

Review

Towards Improved Understanding of the Applicability of Uncertainty Forecasts in the Electric Power Industry

Ricardo J. Bessa [1,*], Corinna Möhrlen [2], Vanessa Fundel [3], Malte Siefert [4], Jethro Browell [5], Sebastian Haglund El Gaidi [6], Bri-Mathias Hodge [7], Umit Cali [8] and George Kariniotakis [9]

1 INESC Technology and Science (INESC TEC), 4200-465 Porto, Portugal
2 WEPROG, 5610 Assens, Denmark; com@weprog.com
3 Deutscher Wetterdienst, 63067 Offenbach, Germany; vanessa.fundel@dwd.de
4 Fraunhofer Institute for Wind Energy and Energy System Technology (IWES), 34119 Kassel, Germany; malte.siefert@iwes.fraunhofer.de
5 University of Strathclyde, Department of Electronic and Electrical Engineering, Glasgow G1 1XQ, UK; jethro.browell@strath.ac.uk
6 Royal Institute of Technology, Department of Mechanics, SE-100 44 Stockholm, Sweden; sheg@kth.se
7 National Renewable Energy Laboratory, Golden, CO 80401, USA; bri-mathias.hodge@nrel.gov
8 University of North Carolina Charlotte, Dept. of Engineering Technology and Construction Management, Charlotte, NC 28223, USA; ucali@uncc.edu
9 MINES ParisTech, PSL Research University, Centre for Processes, Renewable Energies and Energy Systems (PERSEE), 06904 Sophia Antipolis Cedex, France; georges.kariniotakis@mines-paristech.fr
* Correspondence: ricardo.j.bessa@inesctec.pt; Tel.: +351-22209-4216

Academic Editor: David Wood
Received: 18 August 2017; Accepted: 8 September 2017; Published: 14 September 2017

Abstract: Around the world wind energy is starting to become a major energy provider in electricity markets, as well as participating in ancillary services markets to help maintain grid stability. The reliability of system operations and smooth integration of wind energy into electricity markets has been strongly supported by years of improvement in weather and wind power forecasting systems. Deterministic forecasts are still predominant in utility practice although truly optimal decisions and risk hedging are only possible with the adoption of uncertainty forecasts. One of the main barriers for the industrial adoption of uncertainty forecasts is the lack of understanding of its information content (e.g., its physical and statistical modeling) and standardization of uncertainty forecast products, which frequently leads to mistrust towards uncertainty forecasts and their applicability in practice. This paper aims at improving this understanding by establishing a common terminology and reviewing the methods to determine, estimate, and communicate the uncertainty in weather and wind power forecasts. This conceptual analysis of the state of the art highlights that: (i) end-users should start to look at the forecast's properties in order to map different uncertainty representations to specific wind energy-related user requirements; (ii) a multidisciplinary team is required to foster the integration of stochastic methods in the industry sector. A set of recommendations for standardization and improved training of operators are provided along with examples of best practices.

Broader paper on uncertainty forecasting

Prediction Models Designed to Prevent Significant Errors

By Jan Dobschinski, Ricardo Bessa, Pengwei Du, Kenneth Geisler, Sue Ellen Haupt, Matthias Lange, Corinna Möhrlen, Dora Nakafuji, and Miguel de la Torre Rodriguez

Uncertainty Forecasting in a Nutshell

DOI: *10.1109/MPE.2017.2729100*

Digital Object Identifier 10.1109/MPE.2017.2729100
Date of publication: 18 October 2017

IT IS IN THE NATURE OF CHAOTIC ATMOspheric processes that weather forecasts will never be perfectly accurate. This natural fact poses challenges not only for private life, public safety, and traffic but also for electrical power systems with high shares of weather-dependent wind and solar power production.

To facilitate a secure and economic grid and market integration of renewable energy sources (RES), grid operators and electricity traders must know how much power RES within their systems will produce over the next hours and days. This is why RES forecast models have grown over the past decade to become indispensable tools for many stakeholders in the energy economy. Driven by increased grid stability requirements and market forces, forecast systems have become tailored to the end user's application and already perform reliably over long periods. Apart from a residually moderate forecast error, there are single extreme-error events that greatly affect grid operators.

Nevertheless, there are also forecast systems that provide additional information about the expected forecast uncertainty and estimations of both moderate and extreme errors in addition to the "best" single forecast. Such uncertainty forecasts warn the grid operator to prepare to take special actions to ensure grid stability.

The State of the Art in Forecast Generation

Today, some forecast systems have been developed specifically to predict the power production of single wind and solar units, differently sized portfolios, local transformer stations and subgrids, distribution and transmission grids, and entire countries. Nearly all forecast systems have one thing in common: they rely on numerical weather predictions (NWPs) to calculate the expected RES power production. The way to transform weather predictions into power forecasts depends crucially on the end user's application and the available plant configuration and measurement data. If historical measurements are available, forecast model developers often use statistical and machine-learning techniques to automatically find a relation between historical weather forecasts and simultaneously observed power measurements. If no historical measurement data are available, e.g., for new installations of RES units, the transformation of weather to power is often accomplished by physically based models that consider the unit's parameters to map the internal physical processes.

WP3 End use Workshop Glasgow

"Maximising Value from State-of-the-art Wind Power Forecasting Solutions"
Strathclyde University, Glasgow, 21 Jan 2020

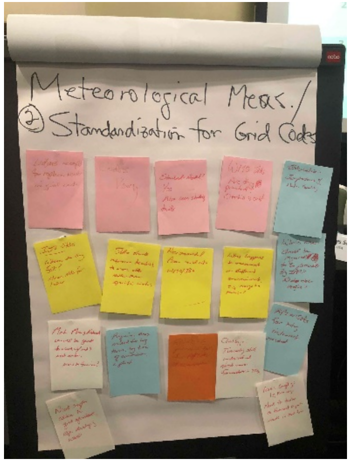
- Talks by academia and industry (e.g. UK National Grid)
- Open Space discussion on RP, data and forecast value
- Game on value of probabilistic forecasts *(feel free to play it yourself!)*: https://mpib.eu.qualtrics.com/jfe/form/SV_d5aAY95q2mGI8El
- Streamed on YouTube: https://www.youtube.com/watch?v=1NOIr7jIuXI


Topic: Meteorological Measurements and Instrumentation Standardization for Integration into Grid Codes

Results from 2 Workshops: ICEM 2019 & WIW 2019

Need for Industry Standard ?

→Need for best practices: BUT too strict standards are worse than non
→ No standards leads to chaotic data management
→ Instrumentation without maintenance: data looses value
→ Maintenance schedules: once, twice per year ?
→ Met instrumentation should be part of the turbine delivery/installation

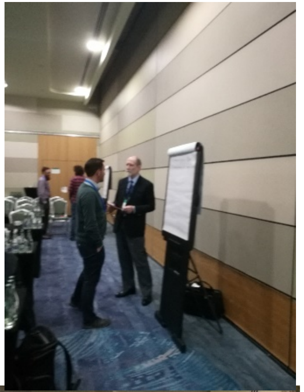


- **Dissemination**
  - No consensus on how to accomplish
  - ENTSO-E is a potential body for dissemination
  - Forecasting still undervalued. Need more forecasters in TSOs.
  - Need simple advice to give operators, especially in the developing world

Topic: Meteorological Measurements and Instrumentation Standardization for Integration into Grid Codes

Results from 2 Workshops: ICEM 2019 & WIW 2019

- **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



05:15 New York // 07:15 Rio de Janeiro // 10:15 London // 15:45 New Delhi // 17:15 Jakarta // 18:15 Peking // 19:15 Tokio

11:15 – 13:00	**SESSION 6A: IEA WIND TASK 36: RAISING THE BAR ON INFORMATION TRANSPARENCY AND RECOMMENDED PRACTICES FOR WIND POWER FORECASTING**
> Session Chair	Gregor Giebel (DTU Wind Energy, Denmark)
11:15 – 12:45	**Presentations (18 min. each)**

- **IEA Wind Task 36 Forecasting – An Overview**
  G. Giebel (DTU Wind Energy, Denmark), W. Shaw (PNNL, United States), H. Frank (Deutscher Wetterdienst DWD, Germany), C. Draxl (NREL, United States), J. Zack (UL Services Group, United States), P. Pinson (DTU Elektro, Denmark), C. Möhrlen (WEPROG, Denmark), G. Kariniotakis (Mines ParisTech, France), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-128)
- **Validation of Numerical Model Improvements through Public Data Sets and Code**
  C. Draxl, J. Lee (National Renewable Energy Laboratory – NREL, United States), W. Shaw, L. Berg (Pacific Northwest National Laboratory, United States) (Submission-ID WIW20-124)
- **IEA Wind Task 36: Practical Application Examples from the Recommended Practices for Forecast Solution Selection**
  J. Zack (UL Services Group, United States), C. Möhrlen (WEPROG, Denmark) (Submission-ID WIW20-108)
- **Wind Power Forecasting Data Definitions and Exchange Standards – An Approach for a Recommended Practice Built upon International Standards and an Eye Towards the Future**
  J. Lerner, M. Westenholz (ENFOR, Denmark) (Submission-ID WIW20-126)
- **Insight on Human Decision-making from Probabilistic Forecast Games and Experience: an IEA Wind Task 36 initiative**
  C. Möhrlen (WEPROG, Denmark), N. Fleischhut (Max-Planck Institute for Human Development, Germany), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-98)

12:45 – 13:00	**Discussions**

05:15 New York // 07:15 Rio de Janeiro // 10:15 London // 15:45 New Delhi // 17:15 Jakarta // 18:15 Peking // 19:15 Tokio

11:15 – 13:00	SESSION 6A: IEA WIND TASK 36: RAISING THE BAR ON INFORMATION TRANSPARENCY AND RECOMMENDED PRACTICES FOR WIND POWER FORECASTING
> Session Chair	Gregor Giebel (DTU Wind Energy, Denmark)
11:15 – 12:45	Presentations (18 min. each)

- IEA Wind Task 36 Forecasting – An Overview
  G. Giebel (DTU Wind Energy, Denmark), W. Shaw (PNNL, United States), H. Frank (Deutscher Wetterdienst DWD, Germany), C. Draxl (NREL, United States), J. Zack (UL Services Group, United States), P. Pinson (DTU Elektro, Denmark), C. Möhrlen (WEPROG, Denmark), G. Kariniotakis (Mines ParisTech, France), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-128)
- Validation of Numerical Model Improvements through Public Data Sets and Code
  C. Draxl, J. Lee (National Renewable Energy Laboratory – NREL, United States), W. Shaw, L. Berg (Pacific Northwest National Laboratory, United States) (Submission-ID WIW20-124)
- IEA Wind Task 36: Practical Application Examples from the Recommended Practices for Forecast Solution Selection
  J. Zack (UL Services Group, United States), C. Möhrlen (WEPROG, Denmark) (Submission-ID WIW20-108)
- Wind Power Forecasting Data Definitions and Exchange Standards – An Approach for a Recommended Practice Built upon International Standards and an Eye Towards the Future
  J. Lerner, M. Westenholz (ENFOR, Denmark) (Submission-ID WIW20-126)
- Insight on Human Decision-making from Probabilistic Forecast Games and Experience: an IEA Wind Task 36 initiative
  C. Möhrlen (WEPROG, Denmark), N. Fleischhut (Max-Planck Institute for Human Development, Germany), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-98)

12:45 – 13:00	Discussions

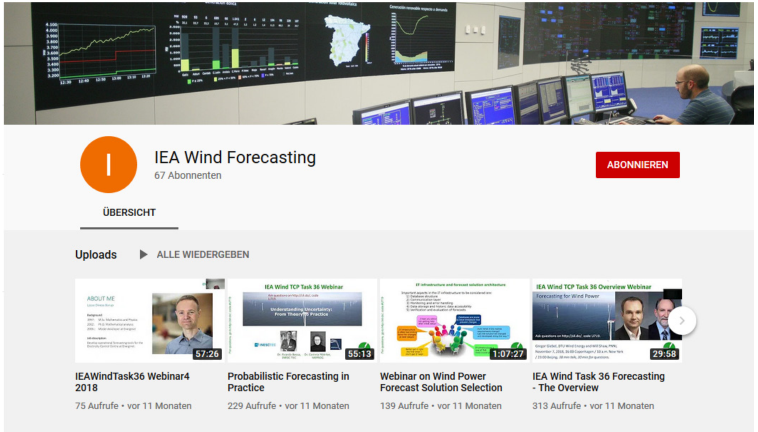
Task 36 Web Presence

Website

www.IEAWindForecasting.dk

YouTube Channel

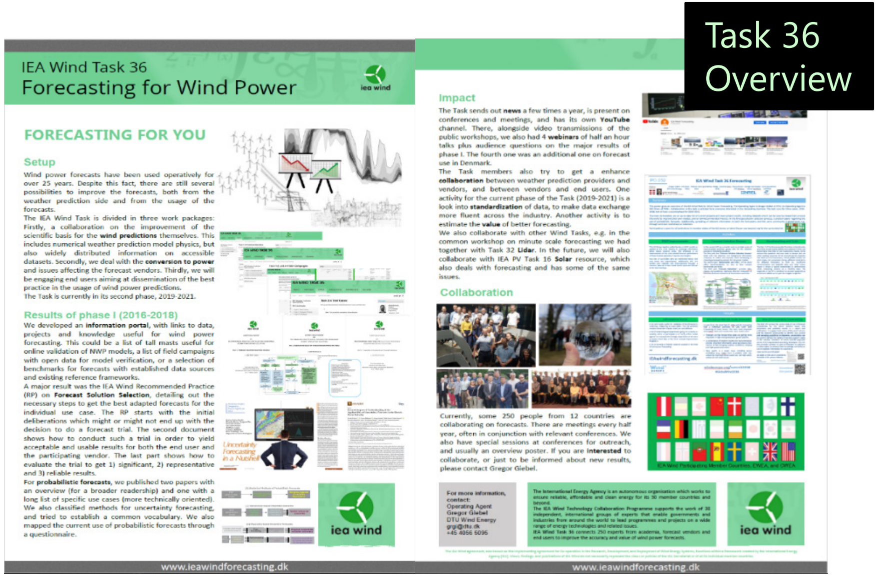
www.youtube.com/c/IEAWindForecasting

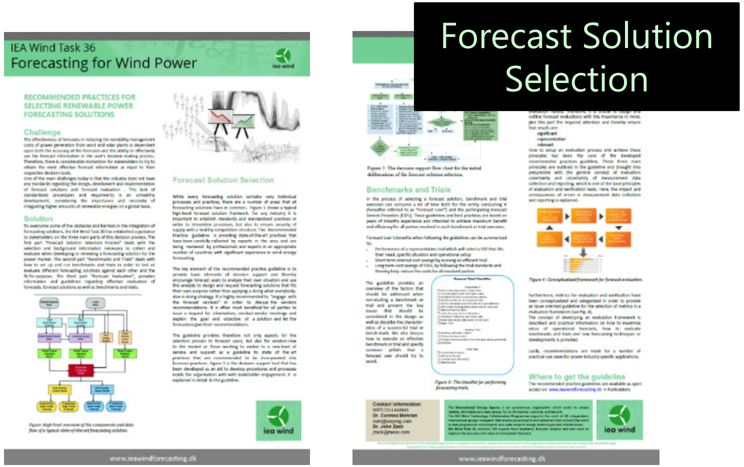


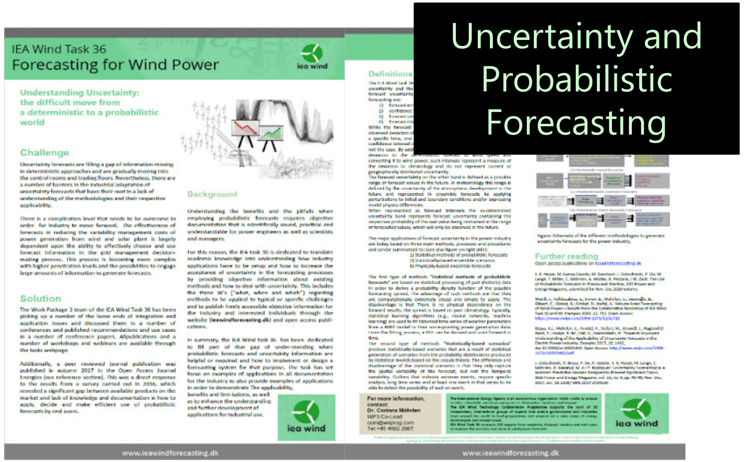
Handouts

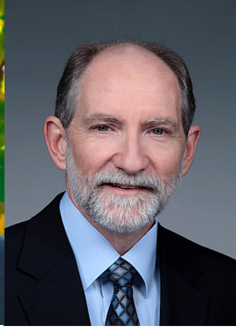
- 2-page handouts: quick overview of major results
- 3 currently available; can be obtained from:

  http://www.ieawindforecasting.dk/publications/posters-og-handouts







www.IEAWindForecasting.dk

Gregor Giebel

Frederiksborgvej 399, 4000 Roskilde, DK

grgi@dtu.dk

Will Shaw, PNNL,

Richland (WA), USA

will.shaw@pnnl.gov

The IEA Wind TCP agreement, also known as the Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems, functions within a framework created by the International Energy Agency (IEA). Views, findings, and publications of IEA Wind do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

05:15 New York // 07:15 Rio de Janeiro // 10:15 London // 15:45 New Delhi // 17:15 Jakarta // 18:15 Peking // 19:15 Tokio

11:15 – 13:00	**SESSION 6A: IEA WIND TASK 36: RAISING THE BAR ON INFORMATION TRANSPARENCY AND RECOMMENDED PRACTICES FOR WIND POWER FORECASTING**
> Session Chair	**Gregor Giebel (DTU Wind Energy, Denmark)**
11:15 – 12:45	**Presentations (18 min. each)**

- **IEA Wind Task 36 Forecasting – An Overview**
  G. Giebel (DTU Wind Energy, Denmark), W. Shaw (PNNL, United States), H. Frank (Deutscher Wetterdienst DWD, Germany), C. Draxl (NREL, United States), J. Zack (UL Services Group, United States), P. Pinson (DTU Elektro, Denmark), C. Möhrlen (WEPROG, Denmark), G. Kariniotakis (Mines ParisTech, France), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-128)
- **Validation of Numerical Model Improvements through Public Data Sets and Code**
  C. Draxl, J. Lee (National Renewable Energy Laboratory – NREL, United States), W. Shaw, L. Berg (Pacific Northwest National Laboratory, United States) (Submission-ID WIW20-124)
- **IEA Wind Task 36: Practical Application Examples from the Recommended Practices for Forecast Solution Selection**
  J. Zack (UL Services Group, United States), C. Möhrlen (WEPROG, Denmark) (Submission-ID WIW20-108)
- **Wind Power Forecasting Data Definitions and Exchange Standards – An Approach for a Recommended Practice Built upon International Standards and an Eye Towards the Future**
  J. Lerner, M. Westenholz (ENFOR, Denmark) (Submission-ID WIW20-126)
- **Insight on Human Decision-making from Probabilistic Forecast Games and Experience: an IEA Wind Task 36 initiative**
  C. Möhrlen (WEPROG, Denmark), N. Fleischhut (Max-Planck Institute for Human Development, Germany), R. J. Bessa (INESC TEC, Portugal) (Submission-ID WIW20-98)

12:45 – 13:00	**Discussions**