



# Wind & Solar Power Forecasting within REMCs

Renewable Energy Expo India 2015  
Green Energy Corridor project & Grid Integration  
IGEF/GIZ/KFW

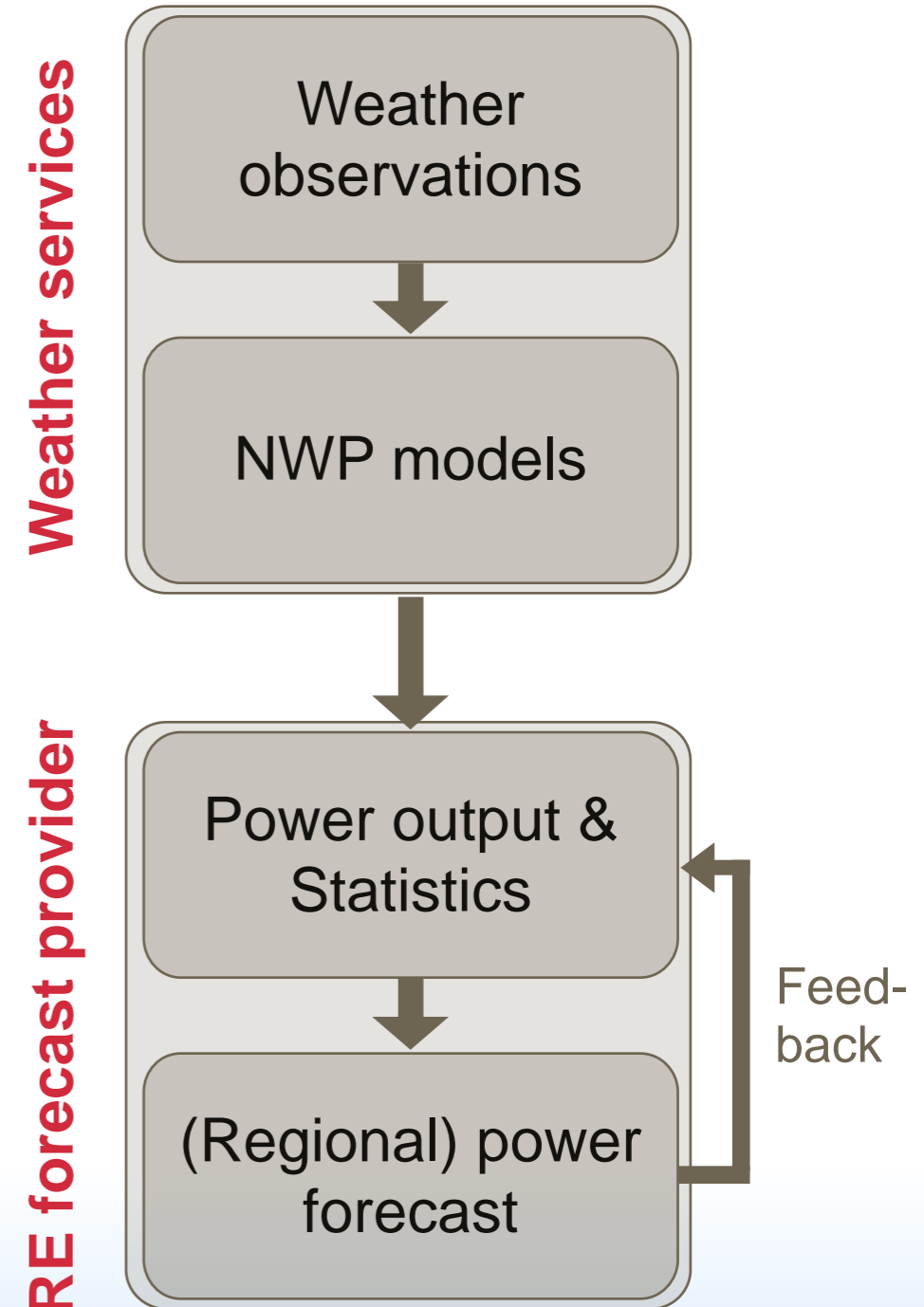
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# Content

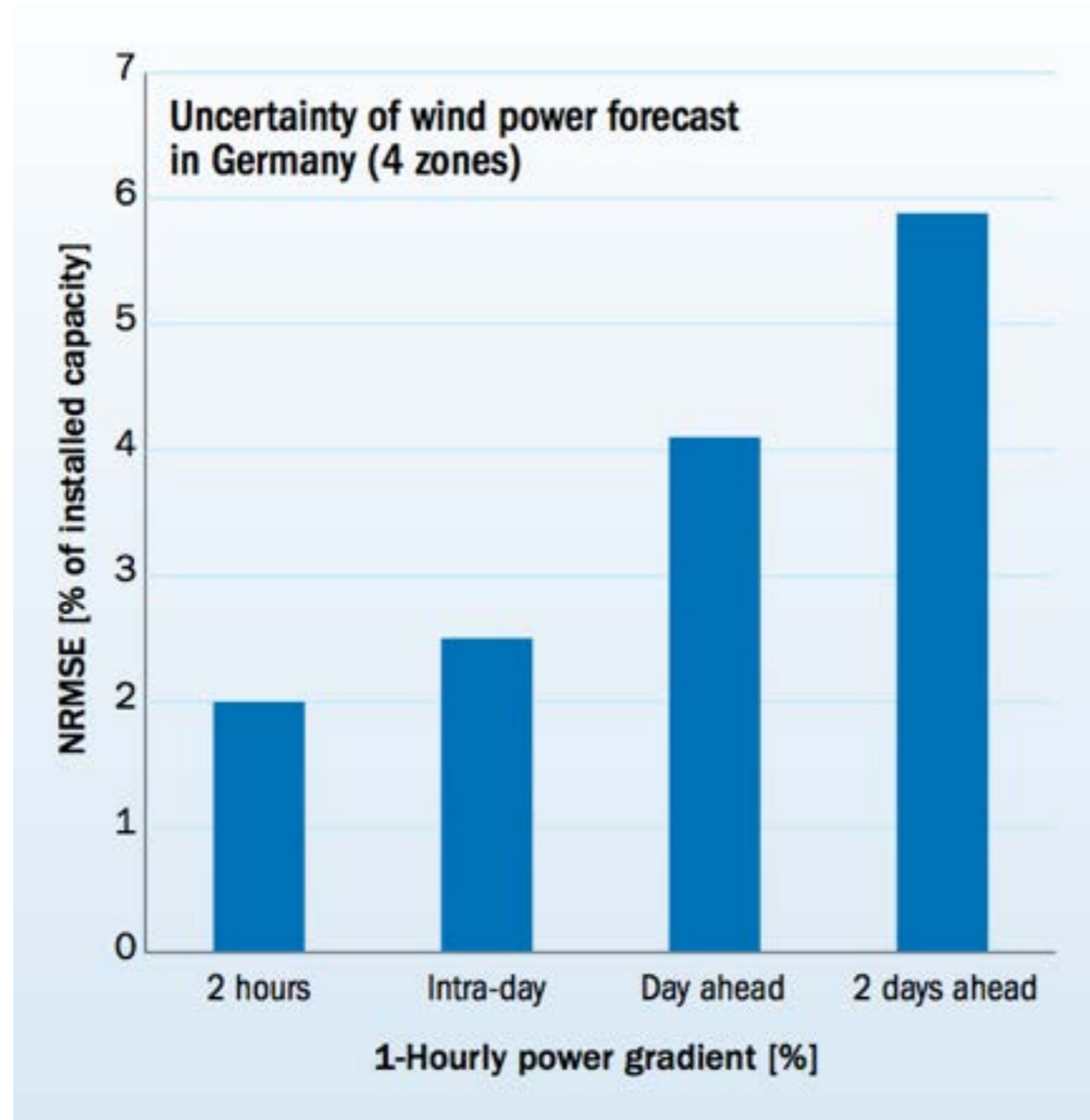
- ▶ Intro: RE forecasting background
- ▶ Forecast accuracy
- ▶ Exemplary forecasting system
- ▶ Implementation of forecasting at REMCs
- ▶ Contribution of India Meteorological Department (IMD) to RE forecasting

# RE Power Forecasting System

- ▶ Weather observations set the initial conditions
- ▶ Numerical weather prediction (NWP) models calculate temporal change of the weather
- ▶ Statistical models relate wind speed (or solar irradiance) to power output and correct for systematic deviations
- ▶ Real power production data provide feedback to correct the statistical model and to update the forecast



# Forecast Accuracy



## Function of Forecast Horizon

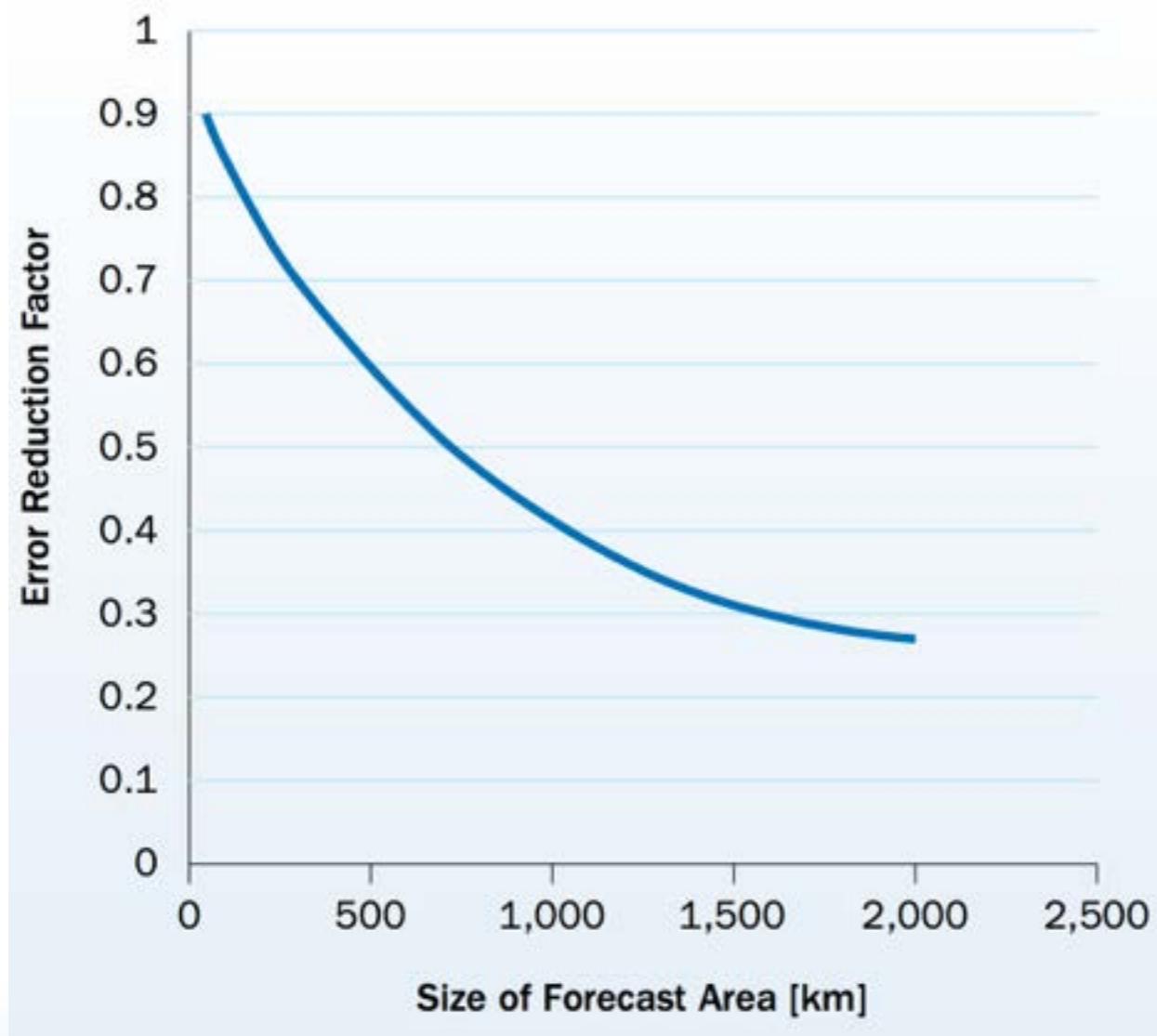
Increasing average wind power forecast error with increasing forecast horizon in Germany

- rRMSE: absolute RMSE divided by the installed capacity
- rRMSE is regarded as international standard for quantifying RE forecast accuracy

One year data, 2009

# Forecast Accuracy

Spatial smoothing effects in larger areas



## Error reduction factor

ratio of:

rRMSE of single turbine forecast

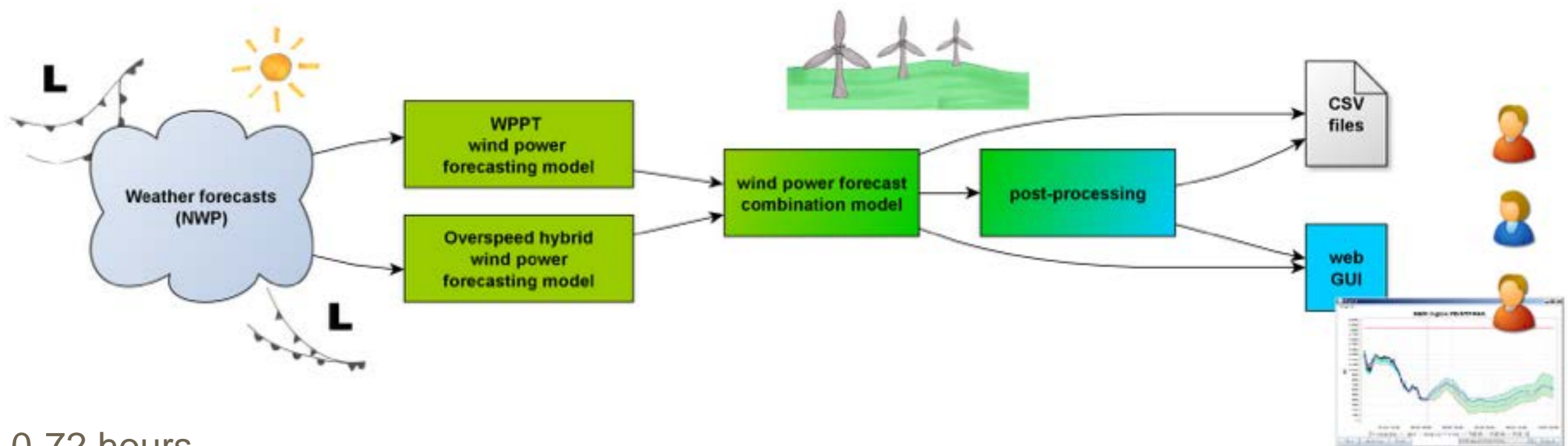
and

rRMSE of forecast for aggregated  
production of all wind turbines in  
the respective area

Ex.: European wind power

# Exemplary Forecast System

Simplified flow chart of a short-term forecast chain (Anemos)



0-72 hours

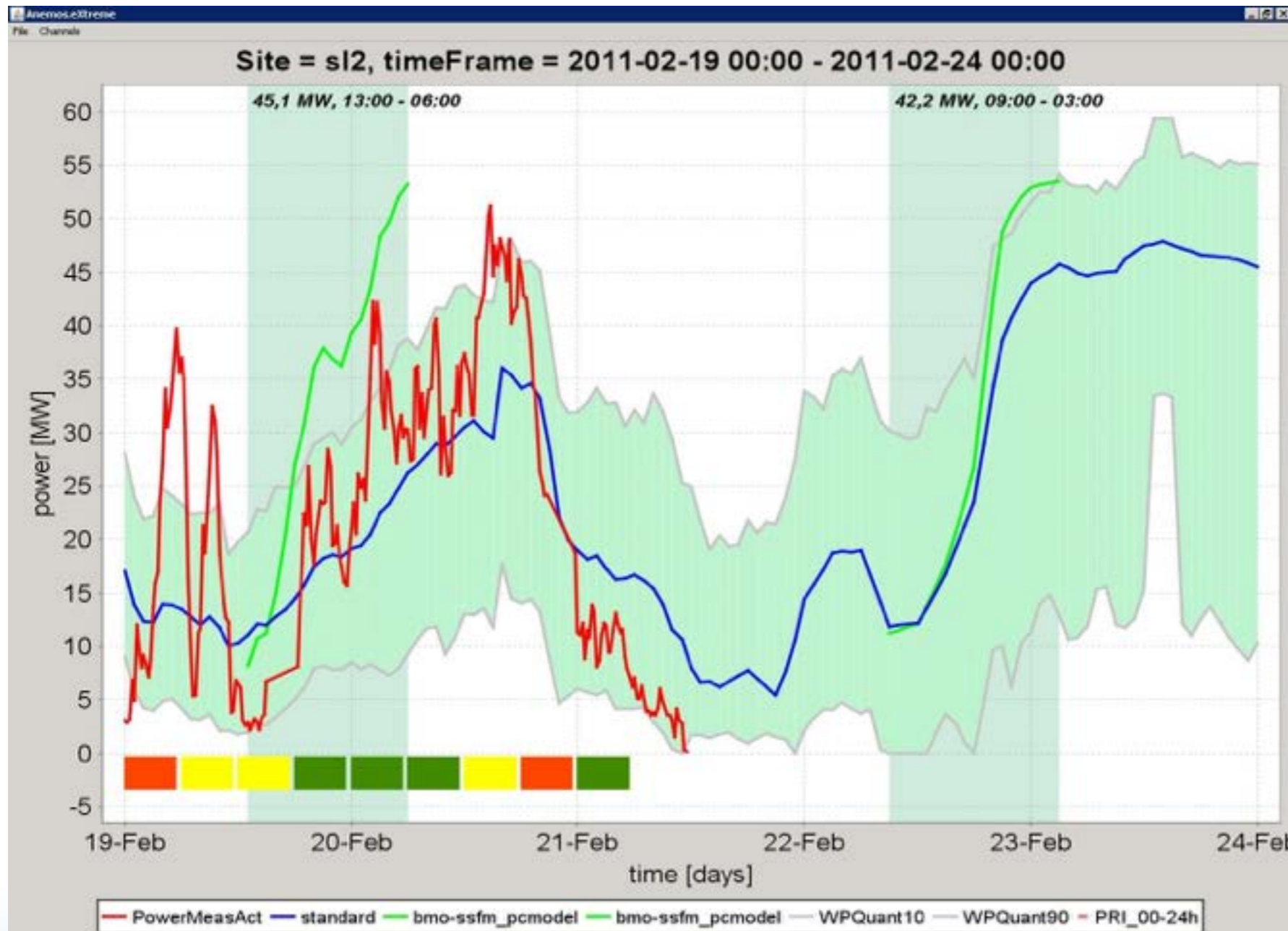
Including: redundant models, forecast combination, post-processing

Post-processing module takes care of grid outages, down regulation and unavailability of wind farms

Solar forecasting chains are similarly structured



# Exemplary Forecast System



## Forecast visualization example

including:

- ▶ deterministic forecast
- ▶ 10% and 90% POE forecast uncertainty interval
- ▶ detected extreme events
- ▶ forecast risk index indicator (coloured boxes at the bottom)

# Typical Forecast 'Chain'

Three stages:

## Numerical weather forecasts

provided by national Met services (or e.g. ECMWF)

This can be:

- Deterministic forecast
- Multi-model forecast
- Ensemble forecast

Weather service

## RE power forecast

NWP products are 'value-added' by provider of RE power forecast services

(post-processing)

- Mostly of statistical nature
- Various combinations possible

RE forecast provider

## Customised forecast

The customers (i.e. TSOs) may themselves perform simple post-processing by combining products of several forecast service providers

Customer level



# Data Requirements for Forecasting

Data sets to be used in wind and solar forecasting in India

- (i) Numerical weather forecasts from Met services (to be collected by RE forecast provider)
- (ii) Static information on installed wind and solar capacity (rated power, type, location, local environment, ...) ...to be collected only once...
- (iii) Online measurement data from operating wind farms  
➔ strong positive impact on forecast accuracy

# Establishment of Forecast System

The RE forecast system should at least provide the following functionalities:

- ▶ Equal treatment of wind and solar
- ▶ Forecast horizons of up to two days
- ▶ Temporal resolution of the forecasts 15 minutes
- ▶ Updates on an intra-day time scale
- ▶ Option for forecasts in the time scale of up to six hours
- ▶ Ramp forecasting (time of occurrence, duration, magnitude, ramp rate)
- ▶ Detailed information on forecast uncertainty
- ▶ Capability to make use of on-line measurement data
- ▶ Continuous forecast evaluation according to state-of-the-art accuracy measures

## Establishment of Forecast System

- ▶ Concentration of forecasting on regional level  
—> significantly lower uncertainties due to spatial smoothing effects
- ▶ No need for single site forecasting – except for economic reasons given by market mechanisms
- ▶ RE forecasting needs to be accompanied by load forecasting scheme of same accuracy
- ▶ Standardised forecast evaluation
- ▶ Establishment of training program (basic meteorological concepts, post processing techniques, probabilistic methods, forecast evaluation, load forecasting)
- ▶ Build-up of expertise on RE forecasting at REMC level

## Renewable Energy Management Center (REMC)

- ▶ Extension of the functionality of the xLDCs towards forecasting and balancing
- ▶ Interface between RE generation and conventional power grid (via xLDCs)  
—> information ‘hub’ for all RE-related data
- ▶ Requirements:
  - ▶ State-of-the-art SCADA functionality
  - ▶ Very high availability
  - ▶ Utilization of existing market standards
  - ▶ Compliance with all IT security standards
  - ▶ Potential for later extension and upgrading without difficulty
  - ▶ Security of investments for at least 10 years
- ▶ IT-specific realization of the REMCs based on standardized SCADA systems  
—> Special report by E&Y to GIZ

## Forecasting at REMCs

- ▶ REMCs run the actual wind and solar power forecasting system locally with very high availability
- ▶ REMCs perform all tasks of forecast post-processing  
—> Combination of forecast data from meteorological services, on-line data from RE systems, and any other related information for the production of optimized forecasts of RE power generation
- ▶ REMCs provide special ramp prediction, and alarming system for extreme situations
- ▶ REMCs handle unavailabilities of RE plants and substations, grid congestions, and RE system down regulations
- ▶ REMCs are responsible for long-term storage of all RE-related data (generation & forecasting)



# Contribution of India Meteorological Department (IMD) to RE Forecasting

- ▶ Running state-of-the-art models Global Forecast System **GFS** and meso-scale forecast system **WRF** (twice daily, 27 km, 9 km and 3 km horizontal resolutions)
- ▶ IMD operates a Multi-model Ensemble (MME) and Ensemble forecasts
- ▶ Operation of High Performance Computing System
- ▶ IMD shows good potential for contributing to a high-level wind and solar forecasting system in India
- ▶ Recommendation to include IMD in solar and wind power forecasting activities due to their huge competence in meteorological forecasting and numerical modeling capabilities
- ▶ Need for training in Energy Meteorology and RE power forecasting

# Thank You!