IMPROVING GRID INTEGRATION OF RENEWABLE ENERGIES:
A SUCCESS STORY BASED ON COMBINATIONAL PV POWER FORECASTS

Dr. Christian Kurz
ABOUT METEOCONTROL
VCOM Cloud

Power Plant Controller

Local SCADA

Smart Yield Prediction

Zero Feed-In

Solar Power Forecast

Control Cabinet

Independent Consultancy

Sensor Portfolio

Supervisory Services

blue’Log X-Series
160 SPECIALIZED EMPLOYEES
12 WORLDWIDE LOCATIONS
45,000 MONITORED PV PLANTS
14 GWP MONITORED POWER
120 COUNTRIES OPERATED
40 YEARS EXPERIENCE
THE IMPORTANCE OF SOLAR POWER FORECASTING

- **O&M**
  Reduce imbalance penalties claimed by the energy market operator

- **GRID OPERATORS**
  Grid integration and security by accurate forecasting

- **ENERGY TRADING**
  Ensure successful trading and market integration of solar power
SOLAR POWER FORECASTS

FOR ENERGY TRADING

- Trading of PV power was a 'day ahead' market for many years
- Now 'intra day' markets become more and more important
- Forecast errors can be reduced by including updated weather information during the day
- New markets are expected to evolve even faster than European markets

Data source: EPEX Spot – European Power Exchange
SOLAR POWER FORECASTS

FOR GRID SCHEDULING

375 Mio. $  Redispatch
540 Mio. $  Feed-in reduction PV / Wind
367 Mio. $  Provision of reserve energy

1,282 Mio. $  Total costs of grid stabilization

Image: TransnetBW GmbH

Data source: Bundesnetzagentur
SOLAR POWER FORECASTS
ON DIFFERENT TIME SCALES

DAY AHEAD
Numerical Weather Prediction (NWP)

SHORT TERM
Satellite observation of clouds
SHORT TERM SOLAR POWER FORECASTING

- 'cloud motion vector' forecasts from satellite images
- Infra red (IR) images for early morning forecasts
- Updated every 15 minutes
- In cooperation with University of Oldenburg
SOLAR FORECAST MODEL

- Satellite Images
- Weather Forecast
- Global Irradiance

PV Power Measurement
Forecast Optimization

POWER CONVERSION
PV Simulation
- Inverter type
- Tilt angle
- Orientation
- Nominal power
- Module type

OPTIMIZED SOLAR POWER FORECAST

SOLAR FORECAST MODEL
- Inverter type
- Tilt angle
- Orientation
- Nominal power
- Module type
MACHINE LEARNING

MACHINE LEARNING is a powerful tool if required information is not available, or no analytical solution is known to solve the problem.
SOLAR FORECAST MODEL

Satellite Images → Weather Forecast → Global Irradiance → PV Power Measurement

Forecast Optimization → POWER CONVERSION

• Inverter type
• Tit angle
• Orientation
• Nominal power
• Module type

OPTIMIZED IRRADIANCE FORECAST → OPTIMIZED SOLAR POWER FORECAST
COMBINATIONAL SOLAR POWER FORECASTS

- Cloud motion from satellite:
  - Precise forecast for the next hours
  - No exact information on actual PV power production

- Numerical weather forecast model:
  - Precise forecast for long time horizons
  - Limited accuracy for the next hours

- Power production from monitoring:
  - Precise information on actual PV power production
  - Limited forecasting accuracy because of changing weather
COMBINATIONAL SOLAR POWER FORECASTS

- persistence (from monitoring)
- cloud motion vector (from satellite)
- Numerical Weather Prediction model

The graph shows the weight of different forecasting models over the forecast horizon (H) from 0 to 5 hours, with the importance of each model decreasing over time.
COMBINATIONAL SOLAR POWER FORECASTS

WEIGHTING FACTORS

forecast horizon: 15 minutes
COMBINATIONAL SOLAR POWER FORECASTS

WEIGHTING FACTORS

forecast horizon: 2 hours
COMBINATIONAL SOLAR POWER FORECASTS

RESULTS

Combined forecast (green) is better than single model forecasts for all time horizons
AVOIDANCE OF 98,000 TONS BY REDUCING REGULATIVE POWER
SUMMARY & CONCLUSION

• PV power forecasts are valuable both for energy trading and grid scheduling

• Day ahead forecasting is ‘state of the art’, short term forecasts becoming more important

• Combined short term forecasts based on monitoring data, satellite images & Numerical Weather Prediction (NWP) models

• Machine learning algorithms for optimum model combination

• Machine learning also helpful to correct stochastic PV plant behavior (shading, soiling, under-performance, …)
THANK YOU!