

# **Forecast solutions for the energy sector**

**ENFOR A/S**

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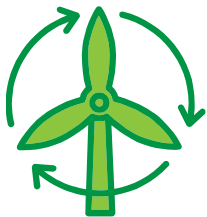
## Consumption and production forecasts



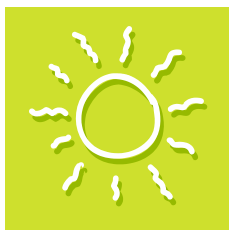
- Heat load forecasts for district heating systems – usually for a horizons up to one week, but up to one month exists.



- Power load forecasts – for horizons up to one week, could be longer.



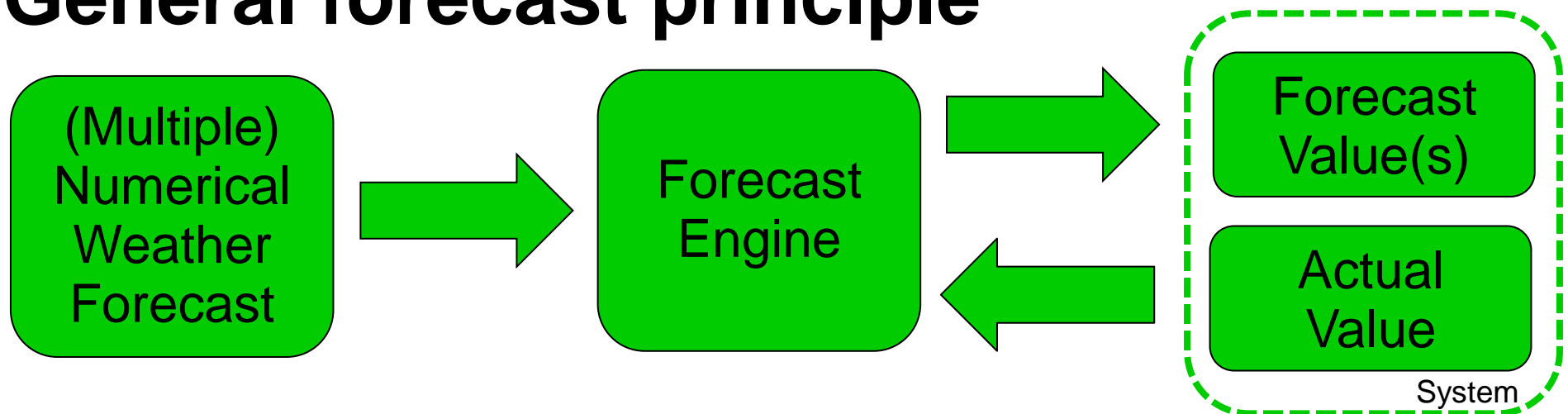
- Wind power production forecasts – usually day ahead, but up to one week is feasible.



- Solar PV power production forecasts – usually day ahead, but up to one week is feasible.



## General forecast principle



- Calibrated against actual production / consumption available on-line or off-line in batches.
- If on-line data is available the autocorrelation is used in order to improve short-term performance.



## Meteorological forecasts (input)

- Systems generally use meteorological forecasts of relevant meteorological quantities (temperature, wind speed, solar irradiance, etc.)
- Any meteorological forecast provider can be integrated, providing that NWP data can be delivered on an appropriate format via the Internet.
- ENFOR is able to provide ECMWF and GFS forecasts as part of our service.



# Price forecasts



- DK1/2
  - Spot price forecasts, based on wind power and load forecasts.
  - Imbalance unit costs.
- UK
  - N2Ex auction prices, based on system messages, including wind power and load forecasts.

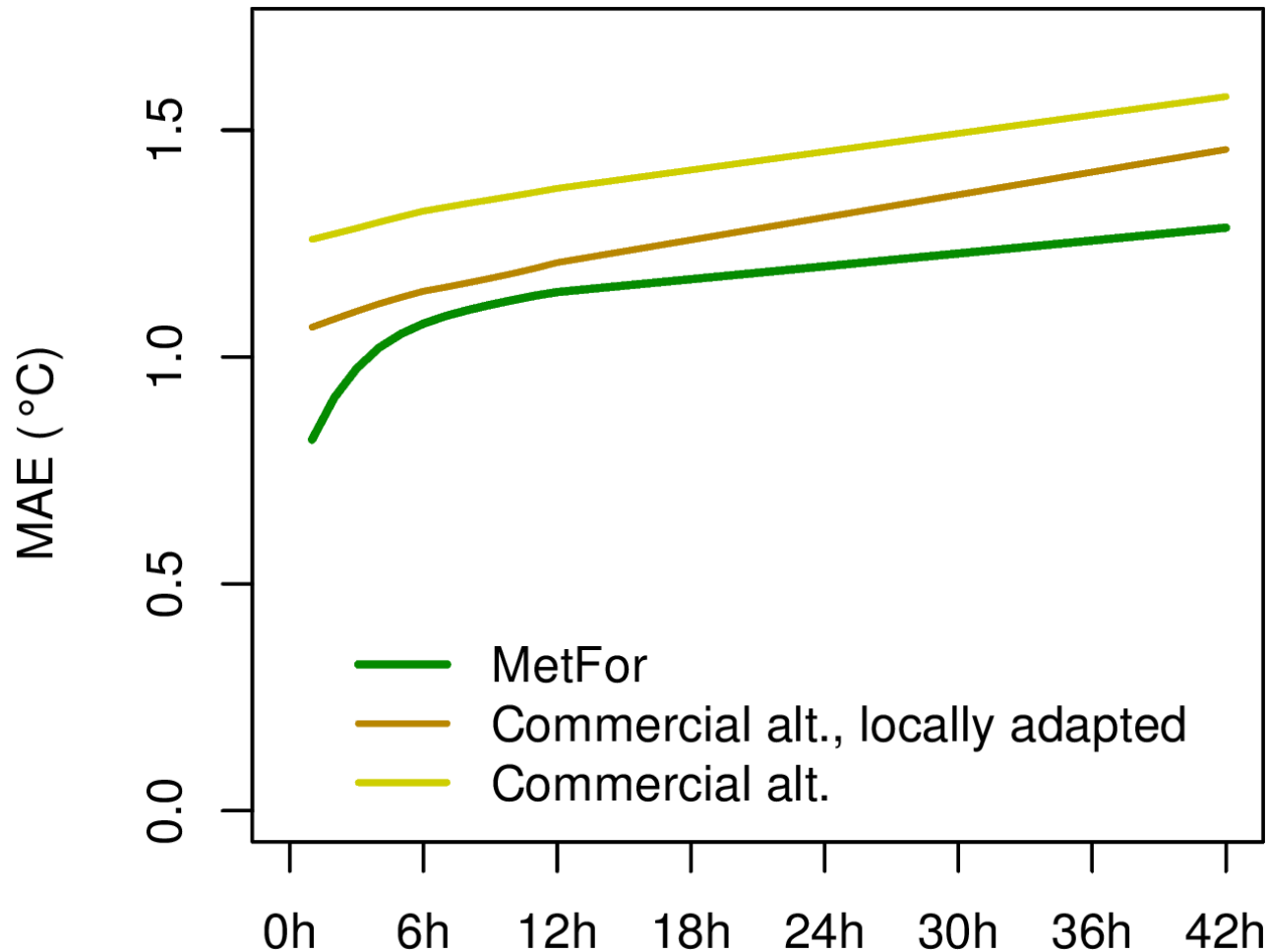


## MetFor

- Standard meteorological forecasts (temperature, wind, sun).
- Calibrated against local temperature measurements.
- Based on optimally combined ECMWF and GFS forecasts.
- Outperforms standard meteorological forecasts.
- Delivered as a service via FTP.



# MetFor performance



Based on:

- Hourly values
- Two years of data
- Three sites



# Wind Power Prediction Tool



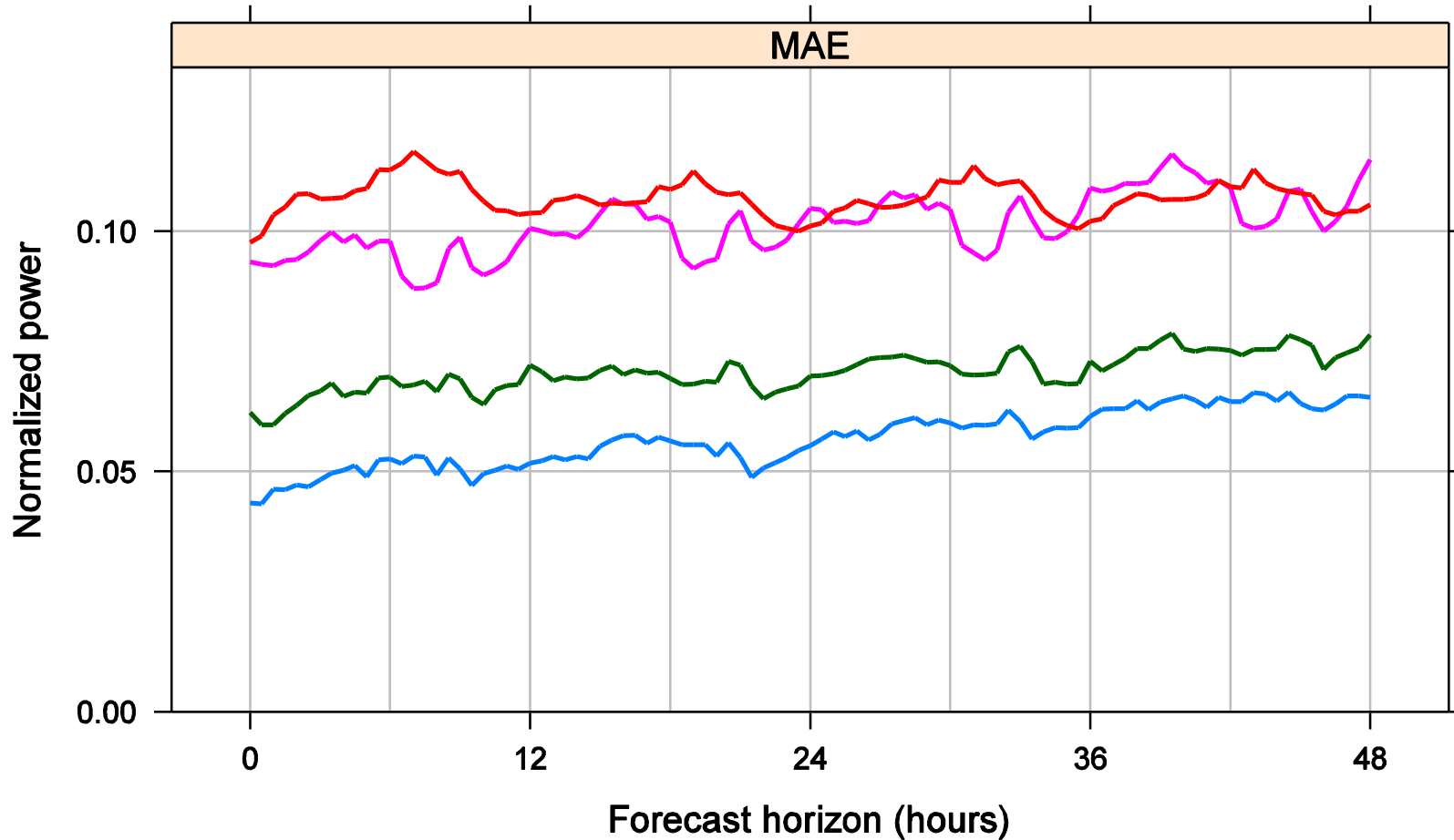
- Highly configurable wind power predictions for farms or regions.
- Handles actual availability and curtailment, including corresponding schedules.
- Available as service or on-site installation.





*No NWP model combination  
No correction for autocorrelation*

WPPT-PC —  
 Simple model —  
 Commercial model 1 —  
 Commercial model 2 —



The plot show performance of four power-curve models, WPPT being one of them. Among the 3 remaining one is a simple model whereas the two others are commercial models. The results are valid for a GW installation consisting of several farms, generally in difficult forecast locations. Evaluation is based on exactly the same data (time points).

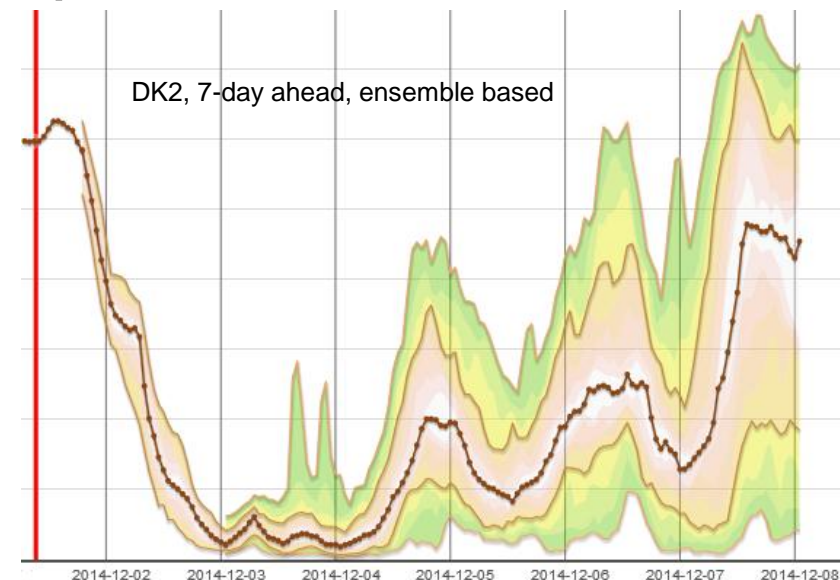


## WPPT modules

- Base
- Optimal forecast combination
- High resolution
- Quantile regression
- Ensemble forecasting
- SCADA upscaling
- Scenario generation



- Shut-down probability
- Icing detection and prediction



# Solar Power Forecasting

- Fixed or tracking systems.
- Advanced pre-processing of NWP data allow forecasts for short intervals.
- Combination of several NWP sources.
- Quantile regression and scenario generation.
- Available as service or on-site installation.



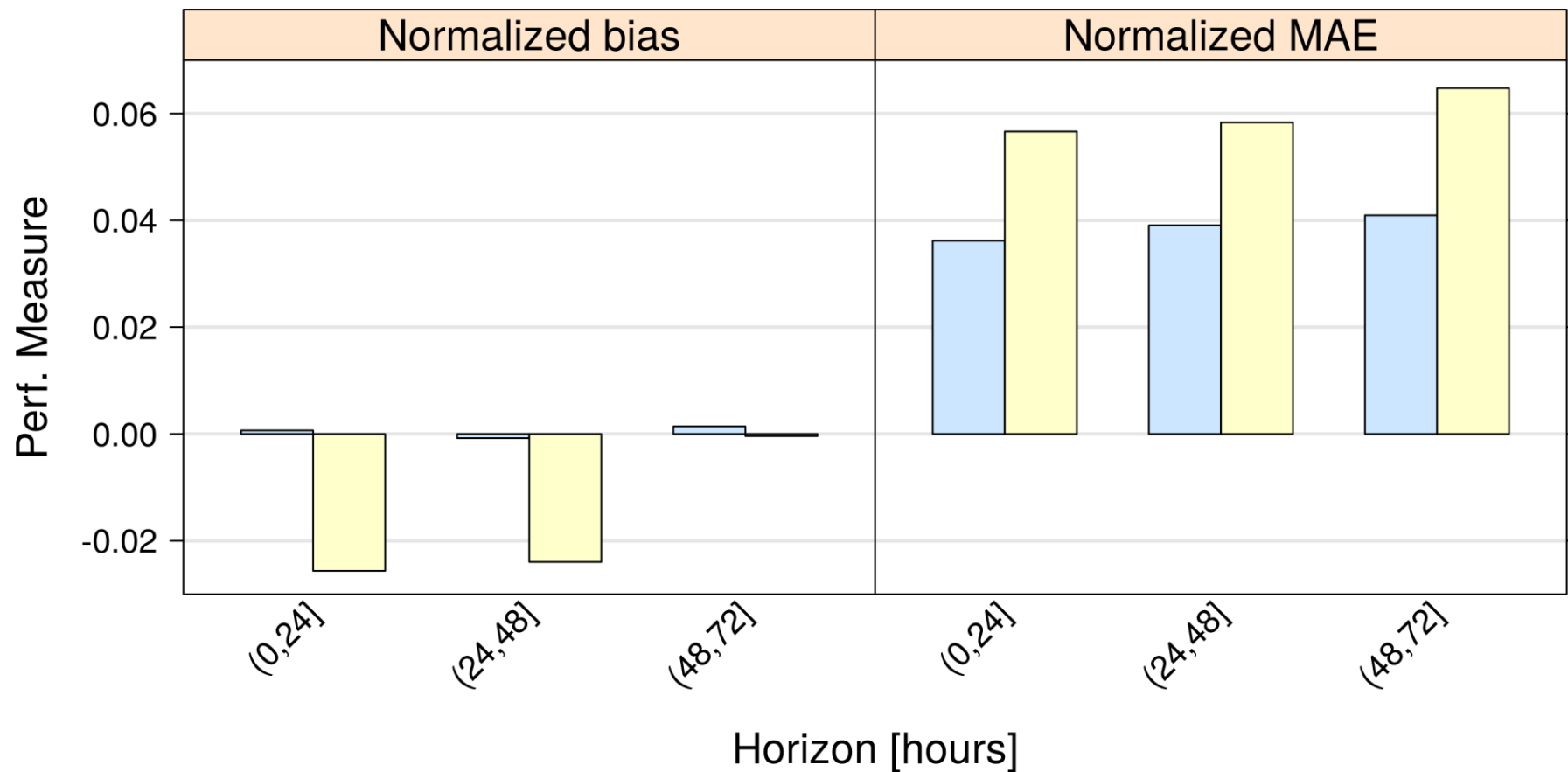
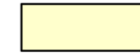
# Comparison of models using ECMWF

No correction for autocorrelation

SolarFor ECMWF



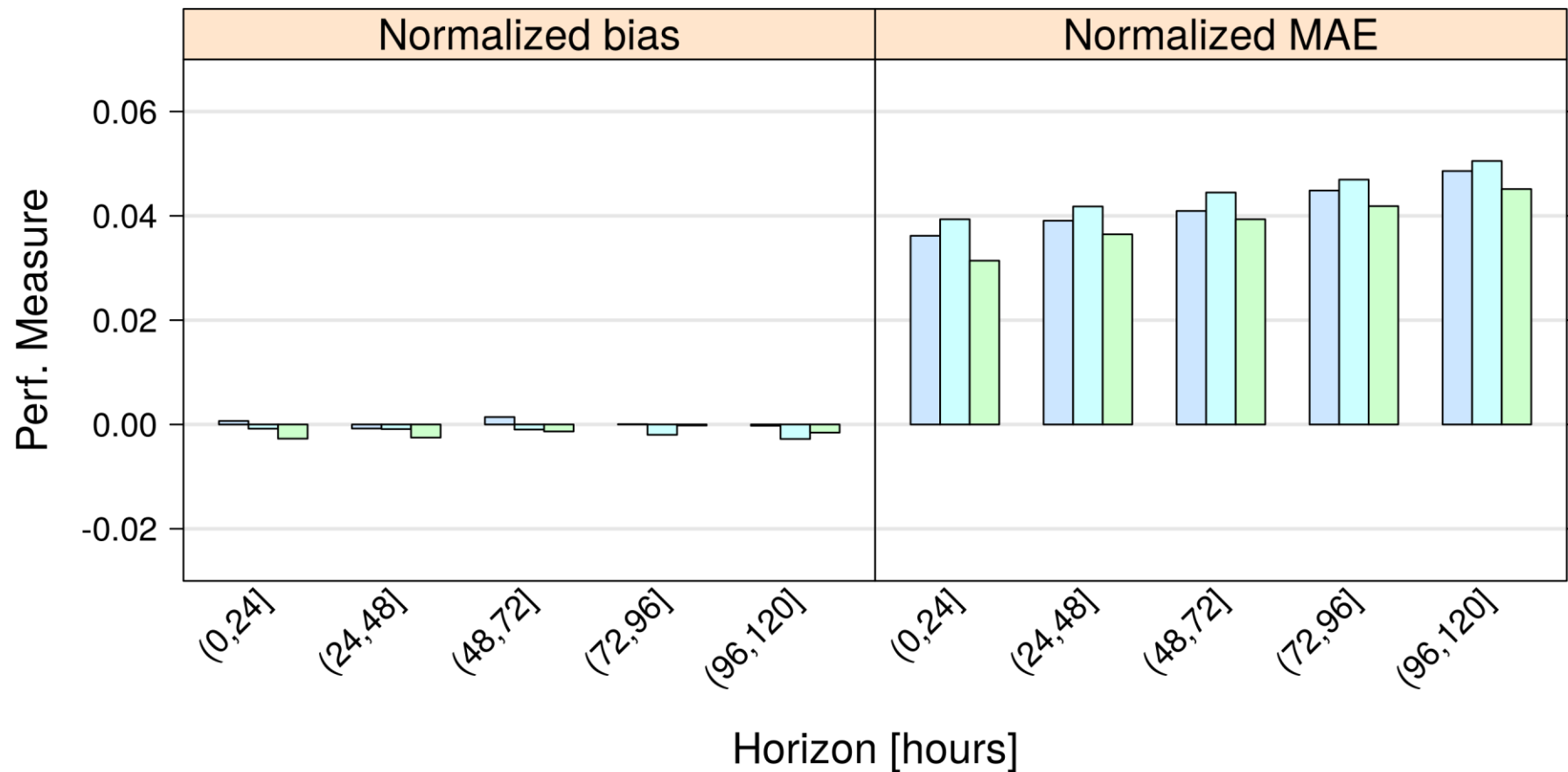
Physical model



# SolarFor using GFS-HD and ECMWF

No correction for autocorrelation

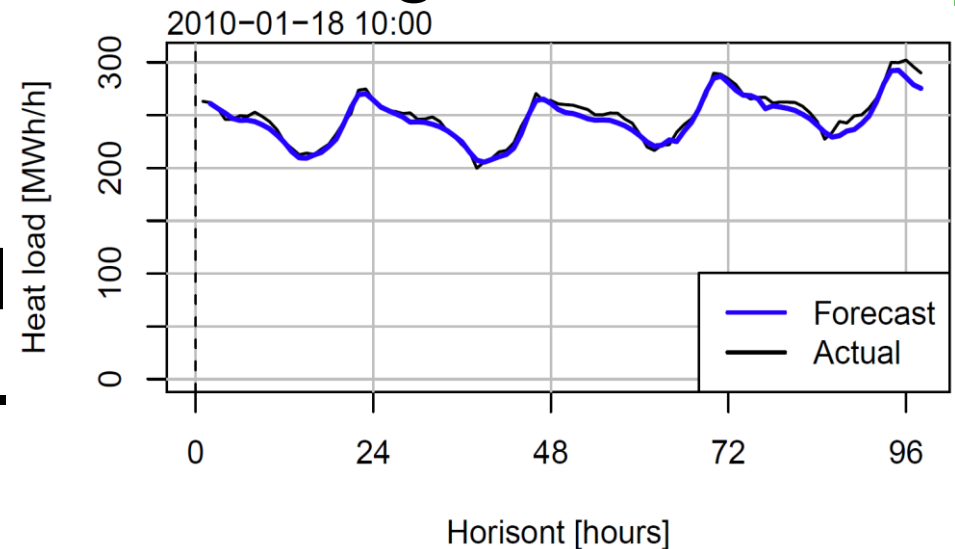
ECMWF    GFS-HD    Combination



# PRESS-Prognosis

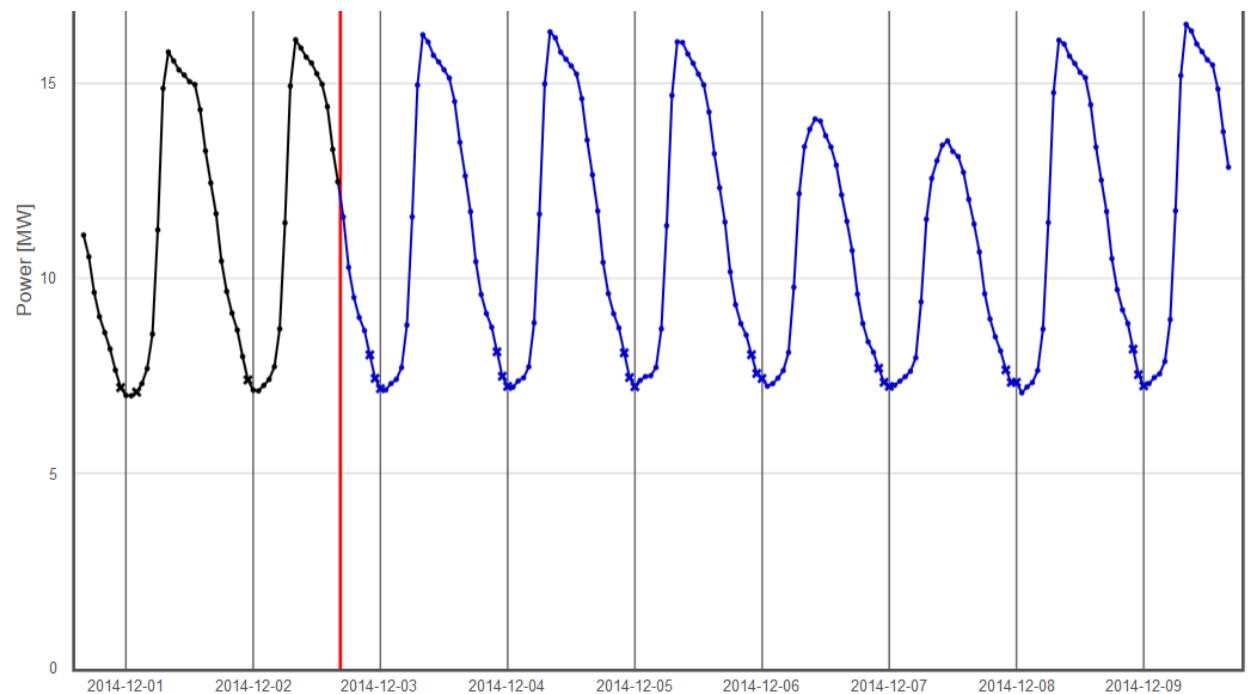


- Use configurable calendar.
- Combination of several NWP sources via MetFor.
- Quantile regression and scenario generation possible.
- Can be extended with supply temperature and production optimization.
- Service or on-site.



# Power Load Forecasting

- Use configurable calendar.
- Combination of several NWP sources via MetFor.
- Quantile regression and scenario generation possible.



## Electricity price forecasting



- Specialized forecasts.
- Developed on a per market / region basis.
- Currently we have solutions for DK (spot prices and imbalance unit costs) and UK (N2Ex auction prices).





## User interfaces



- FTP / SFTP file up- and down-loads with retries and book-keeping.
- Client-specific data interchange (SOAP, XML, ...)
- Highly configurable HTTPS based graphical user interface, supporting access level restrictions.
- Plot data also available as Excel file download.



## **Security of supply**

- Several NWP providers.
- Servers in different data centres.
- Automatic monitoring of server loads, (input) data communication, and forecast delivery.
- Monitoring of forecast performance.



## Data security

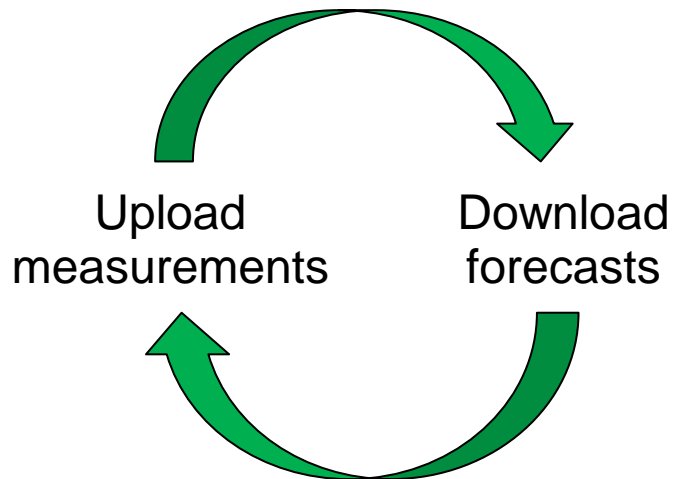


- Firewall only open for client IPs.
- Client data separated via standard LINUX user-level security.
- Clients can only log in via FTP/SFTP or HTTPS, with data separation on login level.
- Encrypted hard disks / servers placed in safes.



# An experimental interface

**Heat load forecast web-service** available as <https://<server>.enfor.dk/press-service/<user>>.



Meteorological forecasts handled automatically by the web-service

**PRESS** web-service

**1** State (refreshes every 5 sec)  
busy: False  
runtime: None  
RESET PRESS

**2** Upload measurement data in CSV-format  
Choose File No file chosen  
Reset Upload

**3** Download forecasts  
Start date:   
End date:   
Reset Download data

**4** Download observations  
Start date:   
End date:   
Reset Download data

**5** Response:

