SYSTEMANALYSE
FORSCHUNGSNETZWERKE ENERGIE

Forecast Optimisation by Correction and Combination methods for System Integration (FOCCSI)

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Gefördert durch:
Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

The research goal:

Low forecasting errors for solar photovoltaic (PV) and wind feed-in forecasts

The research question:

Whether PV and wind feed-in **"meta-forecasts"** with dynamic elastic net outperform: individual forecasts and other benchmarks

Motivation:

a) Net electricity generation from renewable energy sources (RES) in Germany increased from 19.2 % in 2010 to 46 % in 2019;
b) Precise RES feed-in forecasts aim to reduce the uncertainty related to these variable energy sources and to ensure system stability;
c) Short term RES feed-in forecasts are used by: plant operators (to manage power plants and to minimize penalties due to deviation between forecasted and produced energy), system operators (to determine the reserve requirements and to meet real time loads) and traders (to optimize their trading activities)

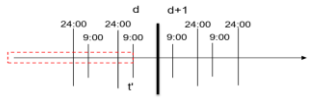
Data:

- covers the period 2012–2018 for PV / 2010–2018 for wind (obtained in cooperation with 50Hertz)
- approximately 25 % / 32 % of total installed PV / wind capacity in Germany
- quarter-hourly, totalling 245,472 / 315,552 realizations of PV / wind feed-in (in MW)
- day-ahead PV / wind forecasts (at 9 a.m.) for feed-in as provided by the different forecasts providers (F1–F6 / F7)

The "meta-forecast":

$$\tilde{\varphi}_t = \beta_{0,t'} + \sum_{i=1}^{m} \beta_{i,t'} \tilde{\varphi}_{it}$$

– $\tilde{\varphi}_{it}$ are the $i = 1, \dots, m$ individual forecasts at t;
– $\beta_{0,t'}$ and $\beta_{i,t'}$ are the combination weights
– the determination of the coefficients is based on historical information available up to: $t \leq t'$



Dynamic Elastic Net (DELNET) with Dynamic Data Pre-processing (objective function):

$$\min_{(\beta_{0,t'}, \boldsymbol{\beta}_{t'})} \frac{1}{2N} \sum_{t=t'-N+1}^{t'} \left(\varphi_t - \beta_{0,t'} - \tilde{\boldsymbol{\varphi}}_t^T \boldsymbol{\beta}_{t'}\right)^2 + \lambda \left[\alpha \|\boldsymbol{\beta}_{t'}\|_1 + (1-\alpha)\|\boldsymbol{\beta}_{t'}\|_2^2/2\right]$$

– $\beta_{0,t'}^*$ and $\boldsymbol{\beta}_{t'}^* = (\beta_{1,t'}^*, \dots, \beta_{m,t'}^*)^T$ - the optimal model coefficients;
– $\tilde{\boldsymbol{\varphi}}_t^T = (\tilde{\varphi}_{1t}, \dots, \tilde{\varphi}_{mt})^T$ - includes the m individual forecasts for each t from the history: $[t' - N + 1, t']$;
– φ_t - the associated realizations of PV and wind power;
– $(\lambda \|\boldsymbol{\beta}_{t'}\|_1)$ - „LASSO"-penalty and $(\lambda \|\boldsymbol{\beta}_{t'}\|_2^2/2)$ - „Ridge"-penalty;
– $\lambda = 0$ - the objective function leads to ordinary least squares (OLS) regression;

PV results:

"Meta forecasts" with **DELNET** outperform the simple average (SA) and best individual forecasts (F2)
- Overall: DELNET has **13.4%** lower RMSE than SA and **4%** lower than F2

Year	RMSE [MW]			
	SA	K	**DELNET**	F2
2012	218	213	**184**	193
2013	272	249	**249**	272
2014	256	295	**249**	263
2015	256	260	**249**	256
2016	261	249	**237**	240
2017	334	277	**274**	277
2018	337	263	**269**	272
Overall	283	263	**245**	255

Wind results:

DELNET forecasts are more precise than SA and F5
- Overall: DELNET Wind or has which is **6.1%** lower RMSE than SA and **3.5%** lower than F5

Year	RMSE [MW]			
	SA	K	**DELNET**	F2
2012	588	623	**552**	627
2013	601	598	**590**	605
2014	579	549	**542**	561
2015	717	684	**656**	688
2016	664	611	**611**	611
2017	755	733	**716**	728
2018	795	708	**717**	721
Overall	660	630	**611**	633

Our contribution:

- We introduce **dynamic data pre-processing** to cope with quality issues in the PV and wind datasets
- Our forecasting framework relies on **DELNET** to address multi-collinearity among the individual RES forecasts
- Our study provides an **empirical contribution to the short-term renewable energy forecasting** literature by using unique, high-frequency datasets for both PV and wind feed-in in Germany
- The framework could have **wider application** for RES forecasting in individual power plants, smaller grid areas, systems, regions or other countries

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