Challenges of integrating wind power from TSO perspective

IEA Wind Task 36 Forecasting

Workshop: Experiences in using Wind Power Predictions and Gaps in Forecasting Research

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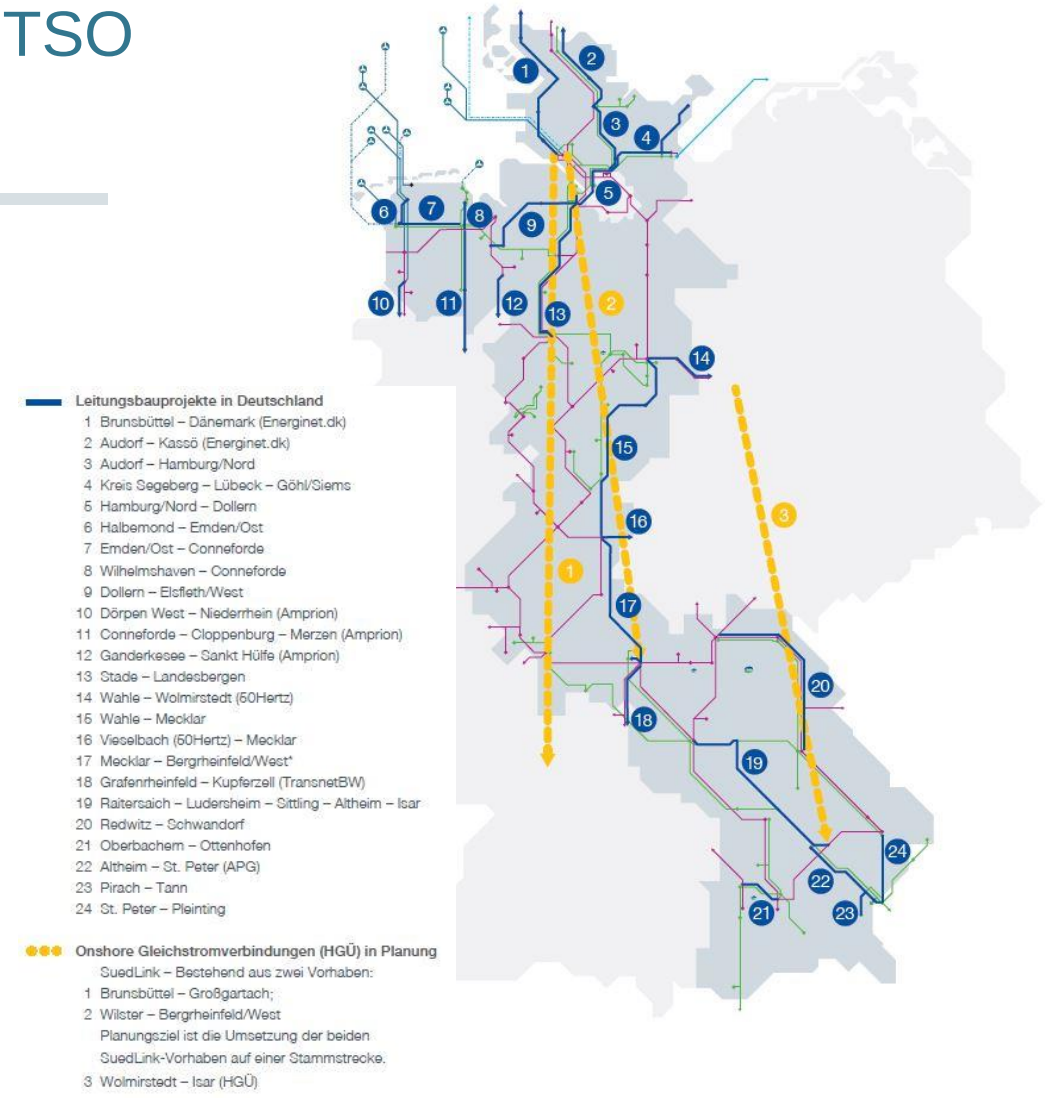
Europe‘s first transnational TSO

Facts & Figures 2015 Germany

Employee	1,476
Sustainable revenue	2,597 Mio. Euro
Financial assets	13,204 Mio. Euro
Imports	52,289 GW/h
Exports	54,255 GW/h
Network length	12,127* km
Number of substations	129
End customer	24,11 Mio.

* Incl. 1,408 kilometers offshore grid connection



Key tasks of a TSO

1 Transmission services

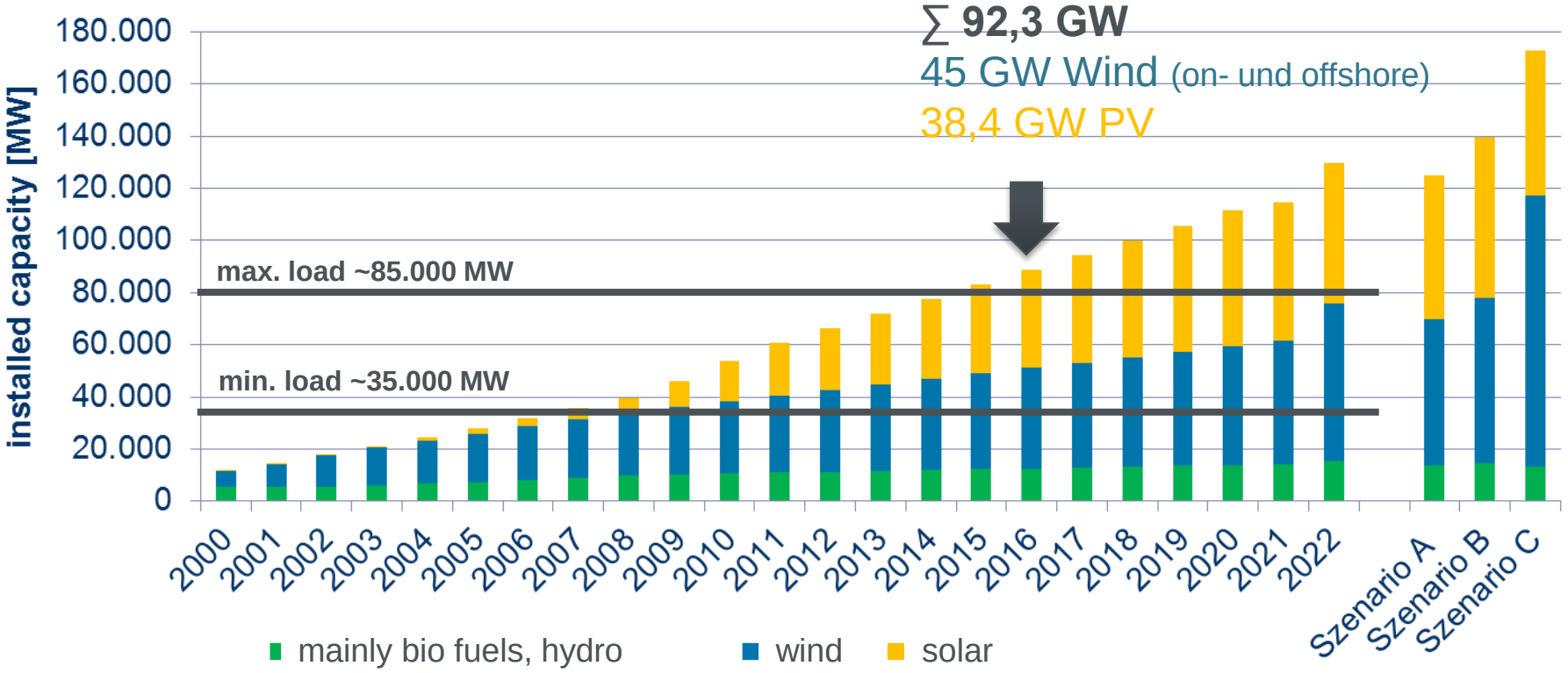
2 Ancillary services

3 Market promotion

Significance for the feed-in forecast RES?

Development of RES in Germany

Forecast of installed capacity of renewables



Further increase of 35% RES share in gross electricity consumption in 2020 to 50% in 2030 and 80% in 2050

Source: BMU, Langfristszenarien und Strategien für den Ausbau Erneuerbarer Energien in Deutschland, 2009

Influences on the power grid

Politic

- EEG-Law
- Support mechanism as regulation

Market behavior

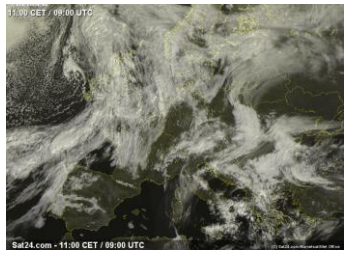
- Direct marketing
- EEG tariff

Population

- Solar self-consumption
- Storage

Weather

- Solar radiation
- Wind speed, direction



RES production

Background in Germany

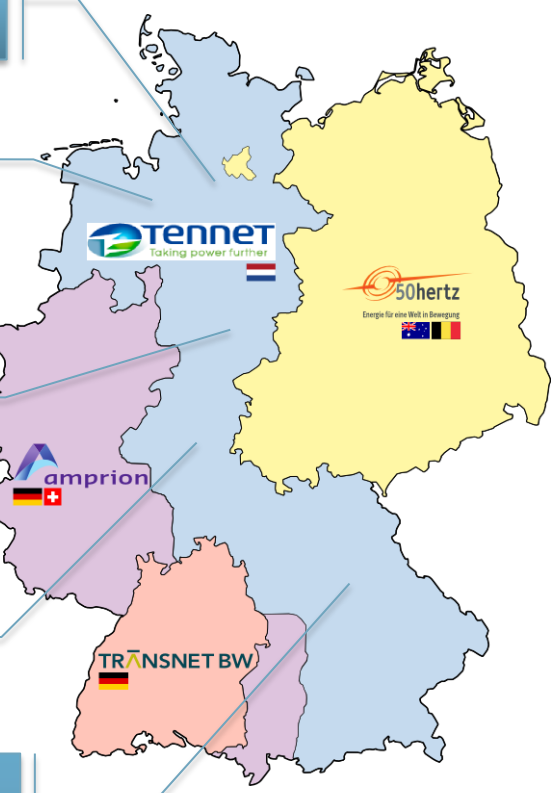
Installed 41 GW RES*

Largest share (~43%) of the “EEG” feed-in* of 4TSO

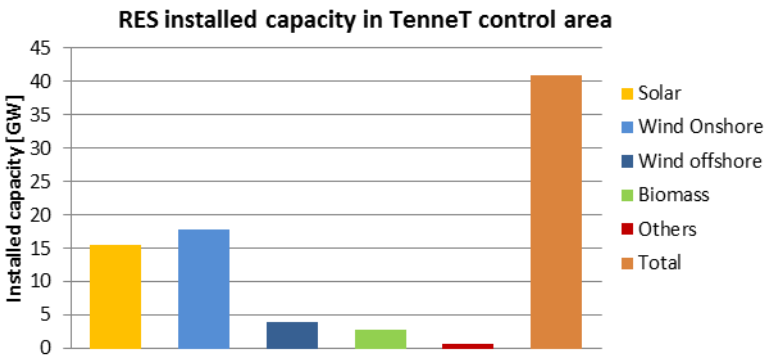
Marketing ~32% of the Germany-wide “EEG” feed-in

Trading in Day-Ahead Market, ¼ hour auction and intraday market

Integrate RES in the system, ensure security of supply



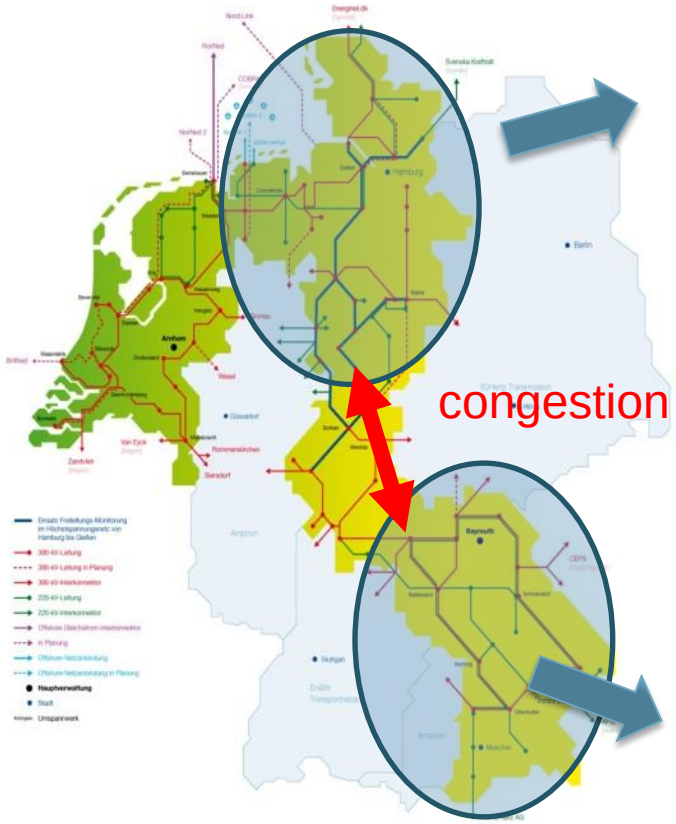
- In the TenneT control area about 41 GW RES are installed - of which 24 GW are directly marketed and 17 GW are marketed via the “EEG” remuneration (~13.6GW Solar, 2.2GW Wind)
- TenneT has the largest share (~ 42.7%) of the “EEG” feed-in of the four control areas (as of 2015/10)
- TenneT markets ~32% of the Germany-wide “EEG” feed-in (HoBA Mechanism)
- TenneT markets in the Day-Ahead Market (hours products), in the ¼ hour auction, in the intraday market (quarter hour products), and OTC according to the legal requirements
- RES has to be integrated in the power system, RES production and RES forecasts are used in System Operation for system stability and security of supply processes

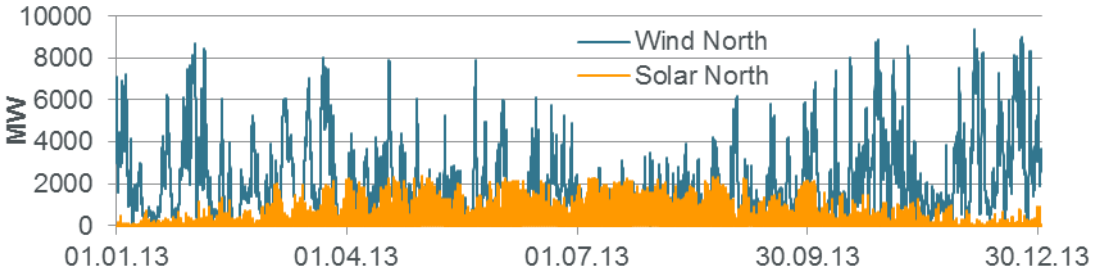


* state 05.2016 for the TenneT region

Wind and PV feed-in

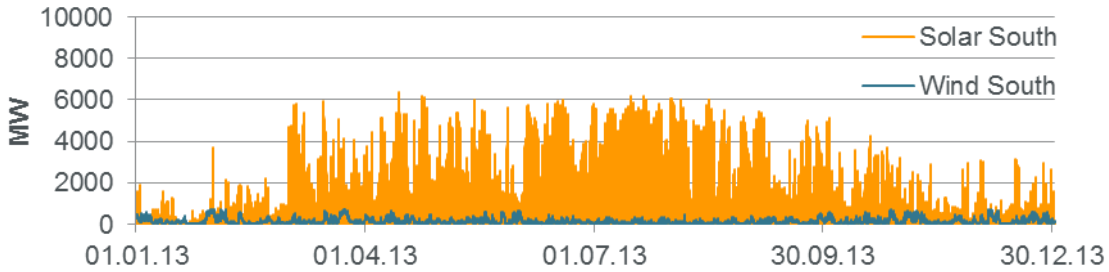
regional distribution within TenneT D





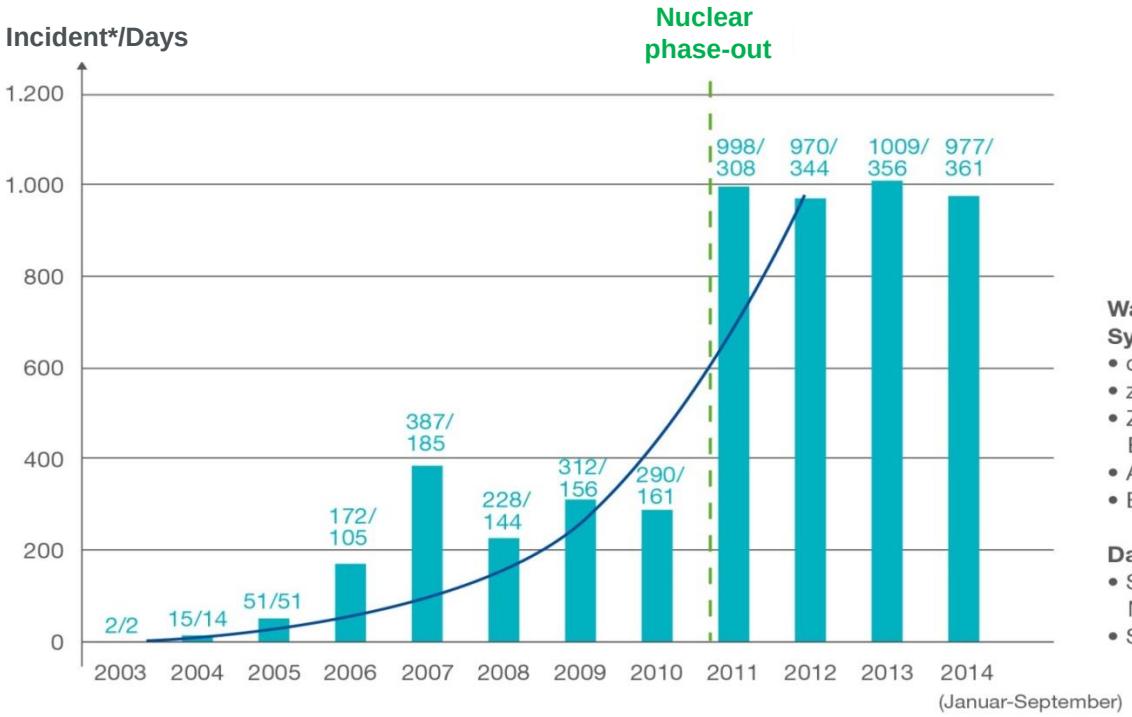
„Windmonth“
North-South-Transport

„Solarmonth“
South-North-Transport



Ensure security of supply

Development of network interventions in TenneT control area since 2003



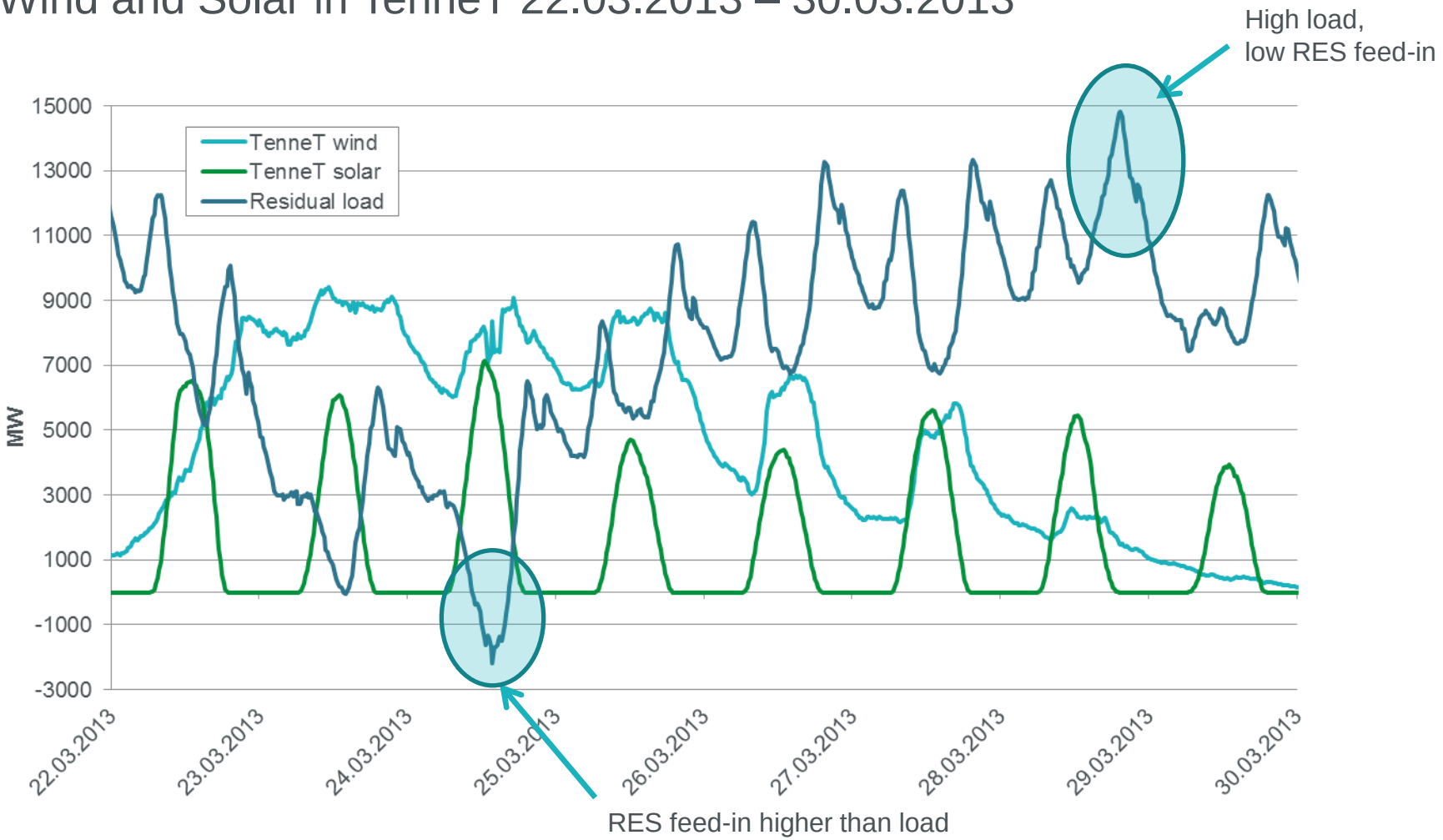
Wachsende Anzahl an Systemeingriffen
- durch lastferne Erzeugungseinheiten
- zunehmende Lastflüsse
- Zunahme von volatilen Erzeugungseinheiten
- Abnahme von konventionellen Erzeugungseinheiten

Daraus resultiert
- Steigender Bedarf von Nord-Süd-Verbindungen
- Steigende Anzahl von Netzeingriffen

*Ereignisse, in deren Folge in der TenneT-Regelzone Maßnahmen nach § 13 EnWG und § 11 EEG ergriffen wurden.

Volatile feed-in RES

Wind and Solar in TenneT 22.03.2013 – 30.03.2013



Planning is required ➡ long-term and short-term forecasts

Application of RES forecasts

System operation

- system stability
- day-ahead congestion forecast
- need of balancing energy

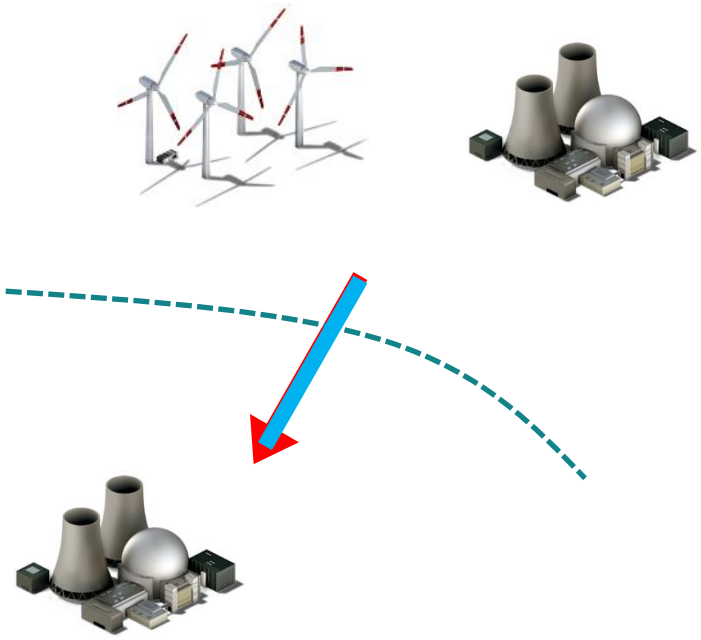
Trading

- even balancing group
- avoid unnecessary trades

Secure system operation

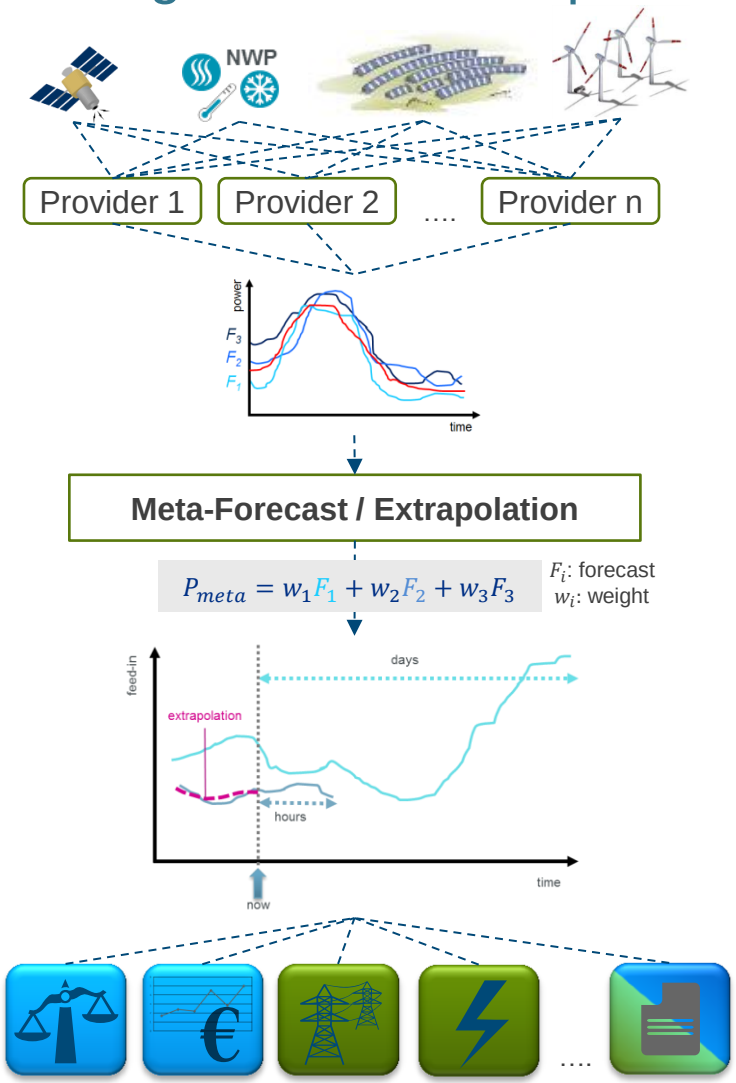
grid security criteria = (n-1) security

- ➡ corrective operations (switching)
- ➡ redispatch
- ➡ feed-in management



RES production forecasting

Background on RES production forecasting in TTG

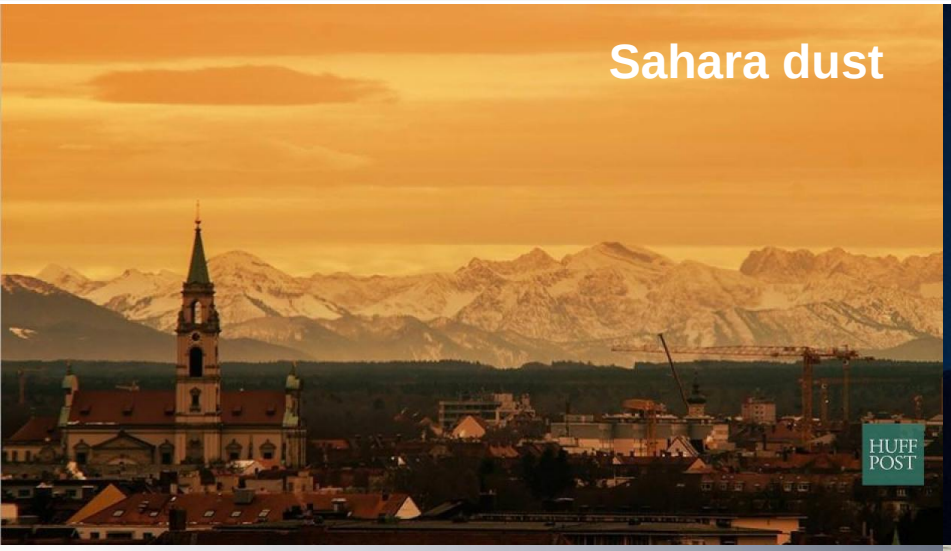


- Deterministic feed-in forecasts for PV and Wind feed-in for various forecast horizons via a combination of different methods (statistical, physically, probabilistically) including a variety of weather models
- The forecasts are separated in a total feed-in and a feed-in according to the EEG
- Creation of meta-forecast by the combination of different forecasts for wind and solar
- Monthly training / optimizing forecast algorithms based on extrapolations of reference measurements and count values for determining the weights of the individual forecasts

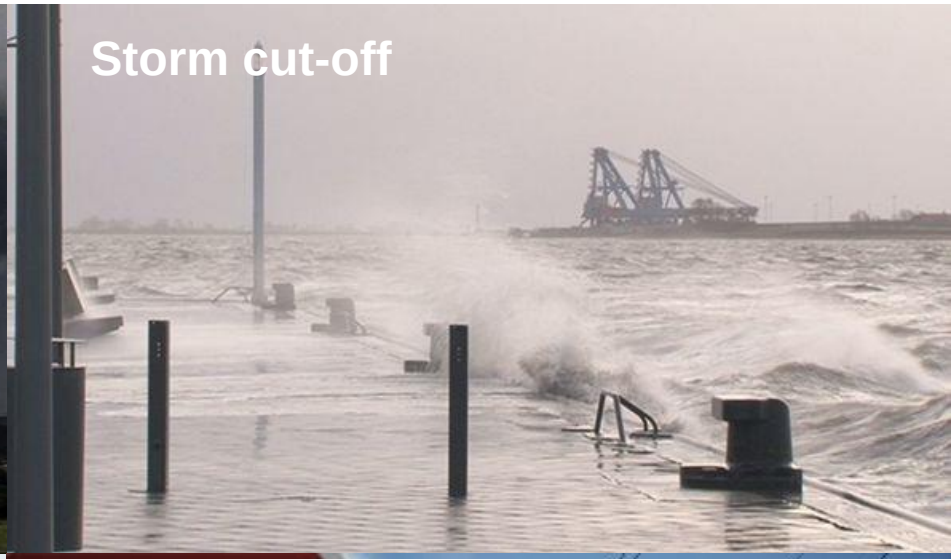
Calculation of w_i

- inverse of the number of forecasts
- use of historic data
- dependent on weather situations
- online correction according to actual feed-in
- experience

Influence of solar feed-in



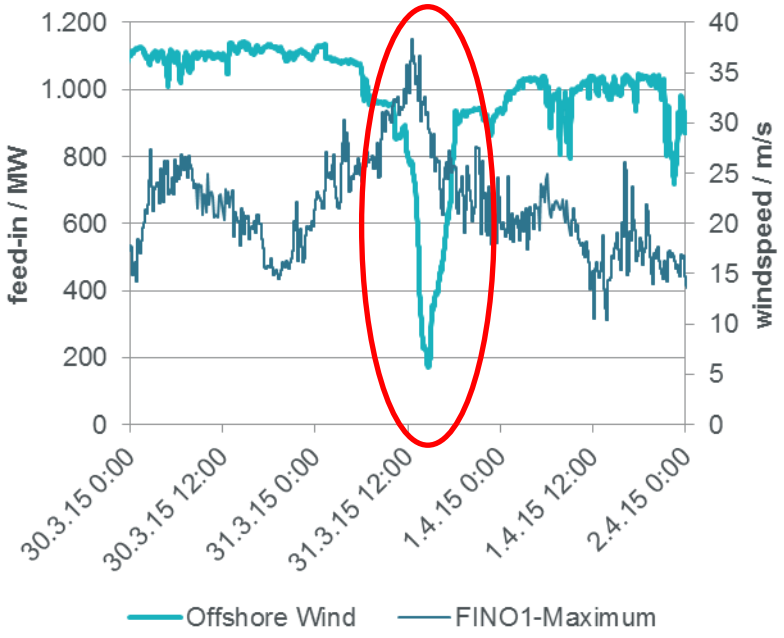
Influence of wind feed-in



Offshore storm cut-off

Example: „Hurricane Niklas“ 31.03.2015

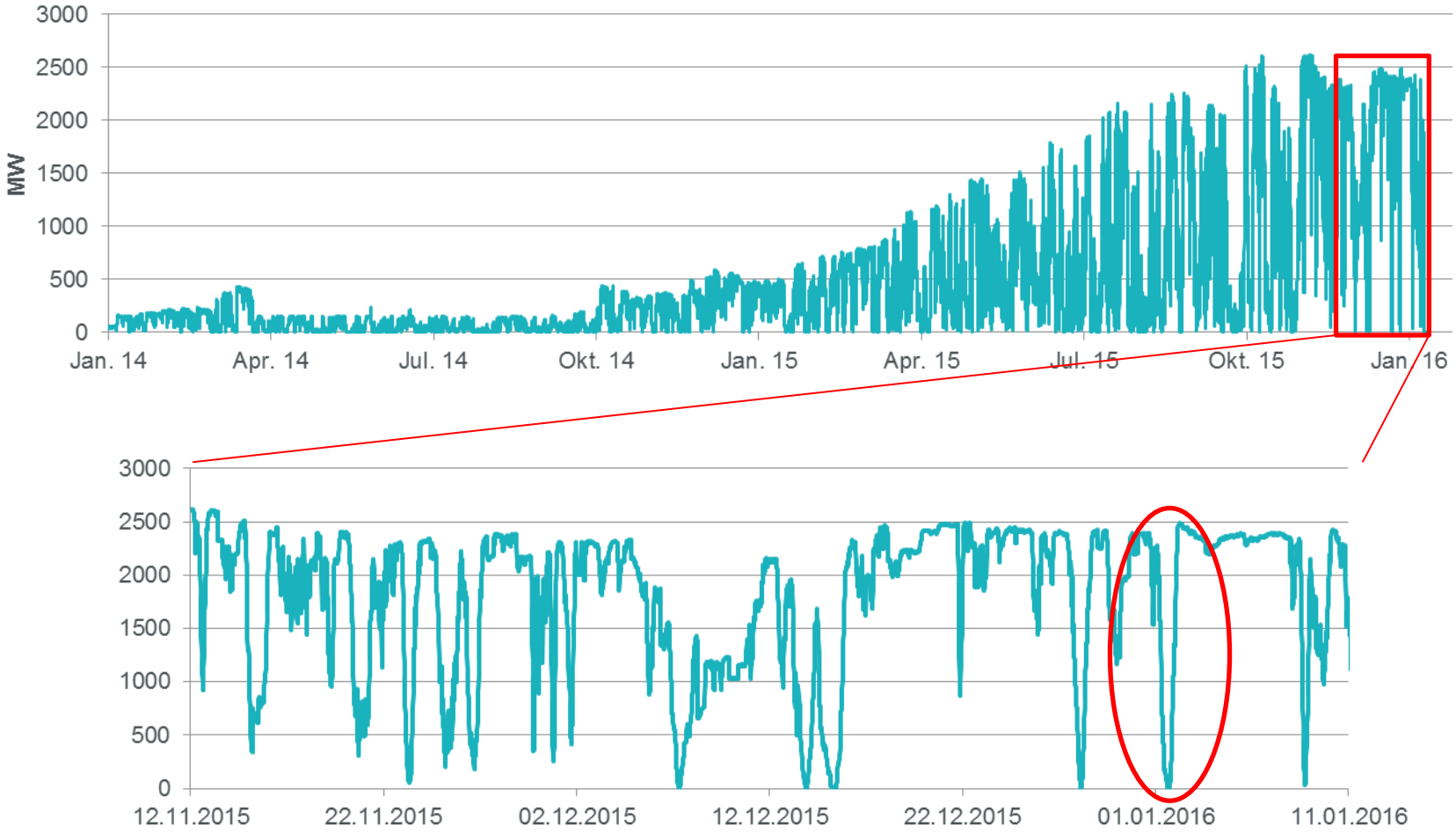
time-delayed switch off (ca. 3 hours)
installed capacity: 1.600 MW



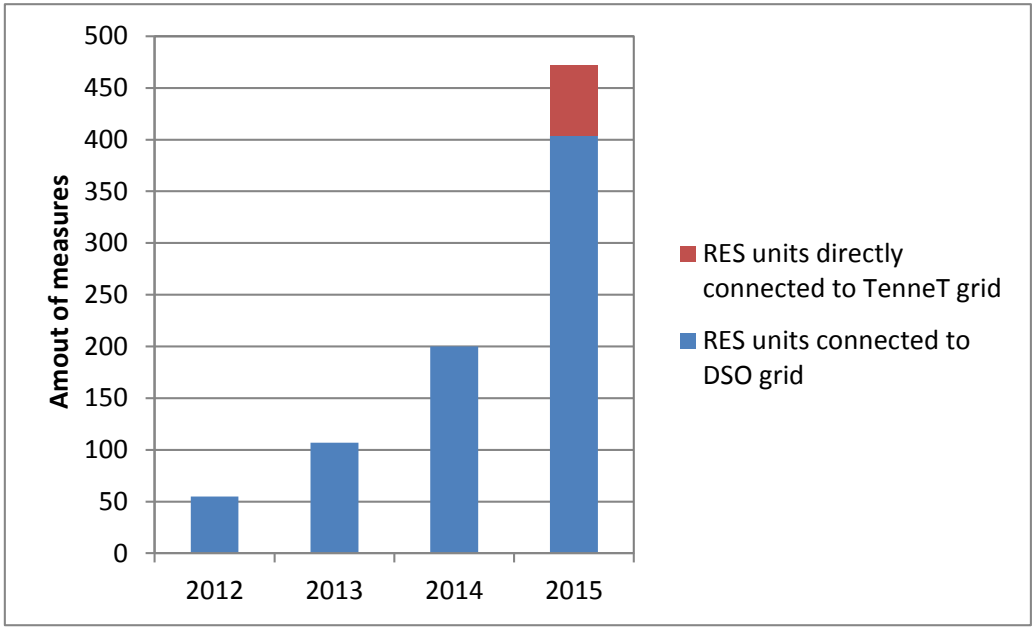
Reduction of offshore wind feed-in from a defined wind speed per wind turbine.
→ Ramps occurs → possible frequency influence
→ possible system balance impact

Development Offshore

October 2015 feed-in of 2600 MW (installed: 3000 MW)

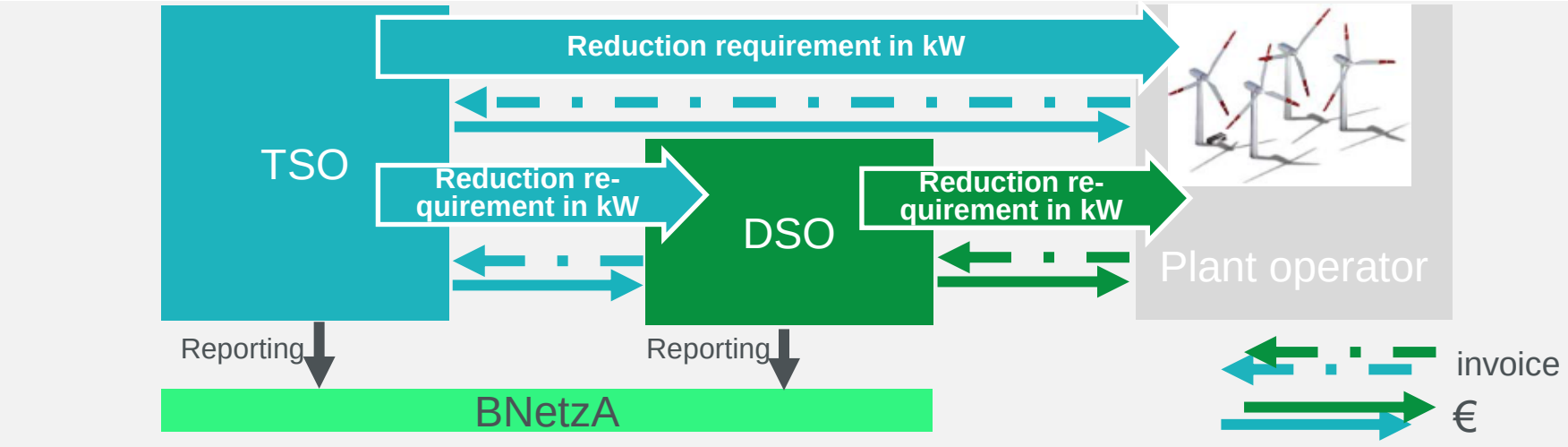


Wind in-feed Management



- Strong increase in Infeed-management activities since 2012 (>900%)
- Only 15% of in-feed management activities with directly connected RES-generation units, about 85% of in-feed management activities based on requirements from TenneT to DSOs
- About 90% of In-feed management activities related to wind turbines, followed by biomass and PV
- In 2015, about 5,200 Wind turbines with a total of 9.1 GW installed capacity have been in in-feed management at least once. Total avoided energy about 3,400 GWh

In-feed management Process



- TenneT requires in-feed management from directly connected RES-generation units (15%) or via DSO (85%)
- RES-generation units receive a compensation in case of an event of in-feed management. The compensation is related to the avoided energy production
- There is a significant time delay (sometimes 3 years) in the settlement process. A financial provision from TenneT is therefore required for these delayed payments
- Financial provision is currently determined based on an extrapolation of avoided energy and an avg. feed-in-tariff

Improvement of Wind extrapolation

Improvement of Wind extrapolation is required in order to minimize the financial risks and to comply to regulatory requirements.

- Develop directly accessible transparent data source
- Data granularity at wind turbine level (5.200 wind turbines in 2015 in in-feed management in TenneT balancing area)
- Calculation of avoided energy per single generation unit based on realized generation and possible generation (without in-feed management)
- Data availability "near time"/real time
- Combination of avoided energy per turbine with relevant feed-in tariff
- Knowledge of feed-in status the moment in-feed management ends

- Regulatory requirement to extrapolate avoided RES infeed energy accurately (reporting to BNetzA)
- Accurate financial provisions will minimize the financial risks
- Setup of a basis for a system based billing process

Improvement of forecasting

Improvement of forecasting RES production is required in order to realize potential economic savings on EEG trade and to minimize the risks on security of supply.

Improvement of forecasting is required

RES production increases due to the energy transition. The improvement of the forecast has 2 business drivers:

1) **EEG Trade:** More accurate RES forecasting will lead to significant Economic savings on EEG trade.

2) **Security of Supply:** Minimizing the risks (and cost?) on security of supply becomes more and more dependant on accurate forecasting.

Current forecasting systems and methods

1. Current Performance is reaching it's limits, due to:
    1. Dealing with high forecast errors.
    2. Late detected incorrect forecasts extrapolations.
    3. Infrequent optimisations.

    This leads to high hidden cost and additional security of supply risks.

2. Current systems and methods are difficult to adapt towards the future requirements (More real-time data, direct optimisation, direct learning and pattern recognition, agility towards changing behaviour)

High level requirements for systems and methods

Improvement of forecasting RES production is required in order to realize potential economic savings on EEG trade and to minimize the risks on security of supply.

Problem	Solution	Measures
• Data is arriving to late (counted data after 4-8 weeks) • Better data granularity is required for calculating the extrapolation • No available data at regional level (e.g. ZIP-Code, Province etc.)	**Increase on Data Quality and New Data Sources**	• Often training minimizes the overall forecast differences • Day-After Data come after 1-7 days • Integration of third-party data • Utilization of local weather measurements
• Incorrect forecast and extrapolation big discrepancies between forecast providers • Current plausibility methods are not complete/ suitable	**Online Monitoring**	• Faster detection of errors, incorrect or missed values on forecasts • Better plausibility measures by comparison • Permanent monitoring and plausibility of online data • Visually online monitoring and warning system
• Extrapolation is systematically oscillating • Systemic errors behind the method used for meta-forecast calculation	**Optimized Meta-Forecast**	• New optimization methods (weighting/ Combination/ Fitting method) • Day-After Data integration • Increase the frequency of calculations (optimally online)
• Extrapolation granularity to low • Forecast granularity to low	**Regionalization**	• Higher data spatial resolution • Improvement by aggregation of local forecast as well as extrapolation

SINTEG Schaufensterprojekte „Intelligente Energie“

Region and Partners	
Region	**Baden-Wuerttemberg, Hesse and Bavaria**
Partners	• 63 project partners
Investment	**120 Mio. €**
Core topics	• Secure networking and automation for market and network processes in the energy system 4.0 • Infrastructure Information System as an advanced infrastructure basis for smart grid and market • Regulatory Innovation Zones • "Cellular approach rather than central thinking"

Region and Partners	
Region	**Counties Aurich, Wittmund, Friesland and the city of Emden**
Partners	• 30 project partners
Investment	**202 Mio. €**
Core topics	• DSO as Smart Grid Operator • Market design for new flexibilities • Smart Data and Services Platform (Big Data) • Energiewende AppStore • Cooperation with start-ups

Region and Partners	
Region	**Hamburg – Schleswig-Holstein**
Partners	• 63 project partners
Investment	**130 Mio. €**
Core topics	• Open technology shift to a production based and flexible energy system • Increase of share of “internal” RES consumption • Flexible industrial loads; Power2Heat-, Power2Steel- and Power2Gas Concepts

In enera, we are focusing on improved forecasting and control of decentralized energy sources

TenneT Demo Projects in enera

Title	Description
e-Now – Energy Nowcasting	• Development of **short-term forecasting of RES infeed** (‘early warning system’) to better manage critical grid situations (DSO, TSO) through – improved forecasting of weather-related influences on the production of wind energy (storms, calms, shutdowns, …) – reduced forecast times from minutes to a few hours in advance – use of new data sources with high temporal and spatial resolution – use of new algorithms (big data analytics) – probabilistic forecasts – localized forecasts • Input in the determination of regional products to be used inter alia by network operators for congestion management
Flexibility and Controllability of System Services by RES **- Wind Energy** **- Energy Storage**	• Development of technologies and processes that **improve cascaded control of actual infeed from wind power and stationary energy storage** • Improved knowledge of the actual control potential of wind turbines and storage systems as well as necessary technological advancements for active and reactive power supply • Storage specific aspects: – Use of energy storage systems for short-term power stabilization – Use of energy storage systems for ‘energy-intensive’ (long-term) storage applications (> 5 h, long-term intake of larger amounts of power, black start capability – Reactive power supply from storage inverters • Set-up of required ICT connectivity and data exchange with all relevant partners

A number of planned TenneT projects are focusing on forecasting and control of decentralized energy sources

TenneT Demo Projects in NEW 4.0

Titel	Description
Forecast of wind, load and storage	• Optimization of wind forecasts, load forecasts and storage forecasts based on new input data (e.g. smart meter data, short-term weather forecasts, mobile sensors, …), big data analyses, probabilistic measures, consideration of extreme weather events and online-analysis of further influences. • Setup of an online information system, probably based on a virtual power plant concept for RES
Direct control of wind turbines	• Controllability of the active and reactive power of distributed wind turbines in distribution networks by the TSO (if necessary) by way of a direct connection of turbines to the systems of the TSO • Build an ICT structure to automate the required processes
Dynamic reactive power from wind turbines	• Development of a standardized market designs for the competitive, dynamic provision of reactive power by decentralized generators • Implementation on an appropriate IT and trading platform

Summary

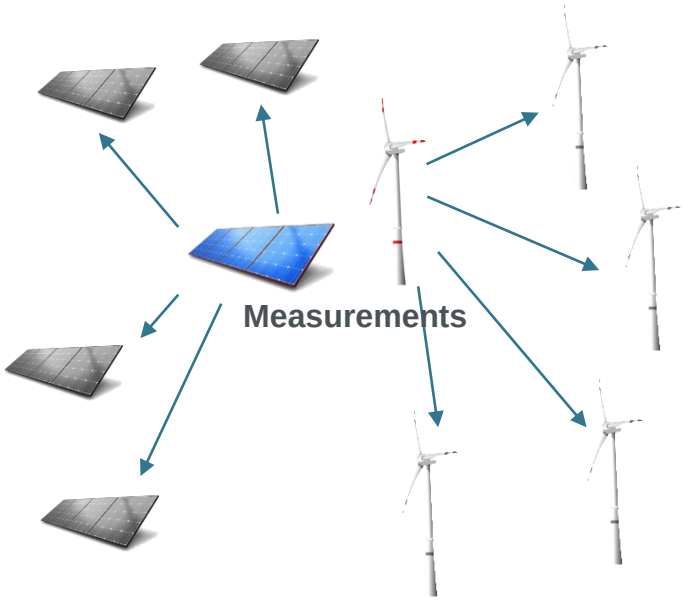
Technical influences

own consumption

Storage

In-feed management

Upscale / Forecast



Meteorological influences

Fog

Snow

Dust

Storm

Applications of forecasting

- load flow calculation (Vorschaurechnung)
- calculation of capacity limit
- feed-in monitoring
- marketing in energy exchange
- grid load, and losses prediction

ONLINE correction

Forecast-optimization

Thanks for your attention!

www.tennet.eu

TenneT is Europe’s first cross-border grid operator for electricity. With about 21,000 kilometres of (extra) high-voltage lines and 41 million end-users in the Netherlands and Germany, we rank among the top five grid operators in Europe. Our focus is to develop a North-west European energy market and to integrate renewable energy.
Taking power further

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