The German energy transition & integration of renewable energy

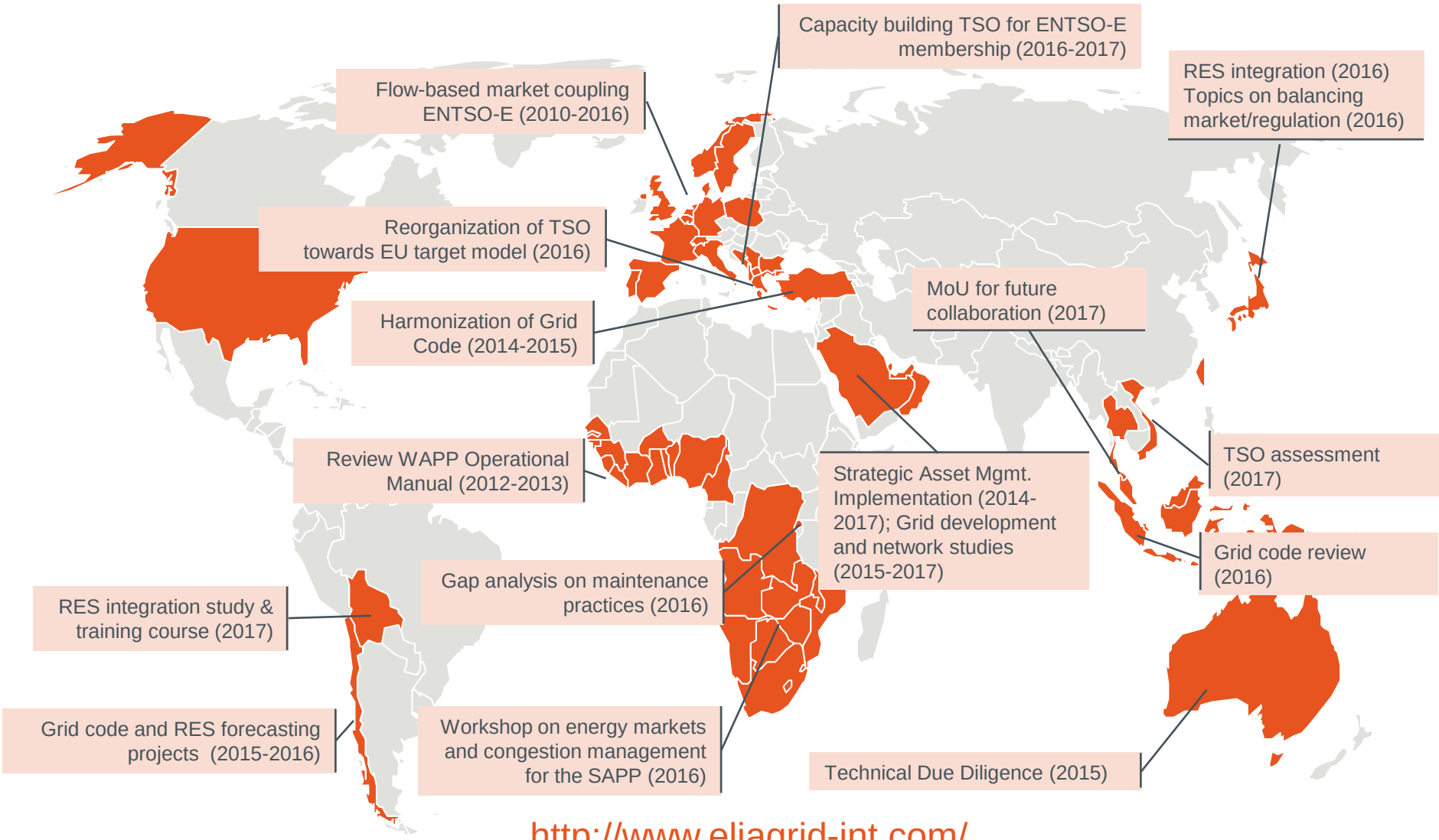
Dispatching and evacuation of RE generation

Manila, June 5th 2017

Dr. Niels Ehlers, Head of Concepts and System Strategy, 50Hertz

50hertz

Elia Grid International – TSO consultancy



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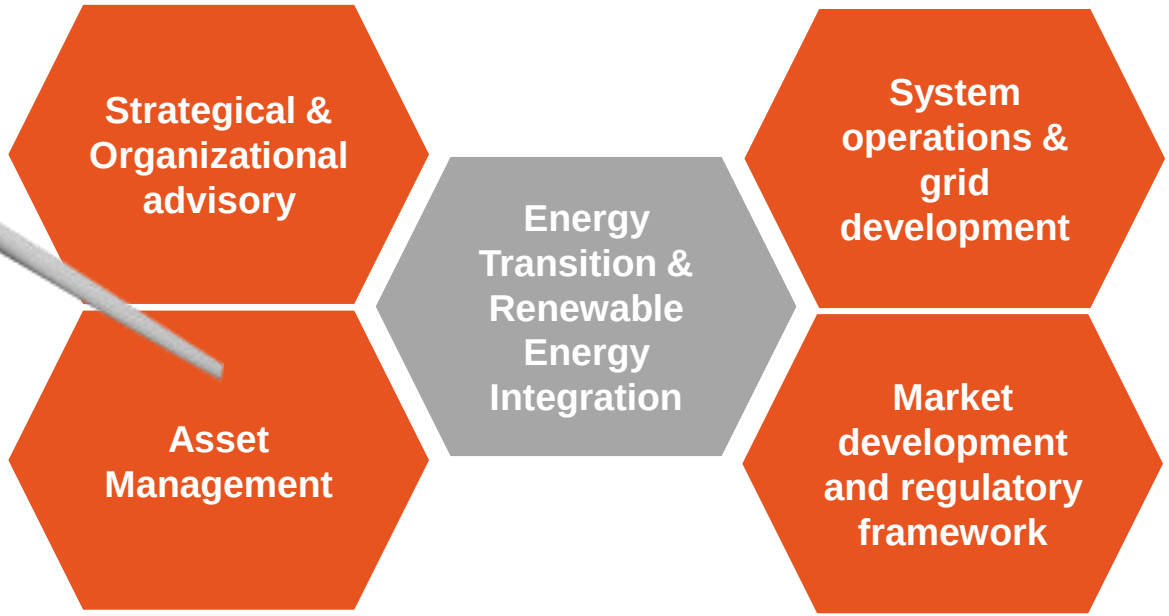

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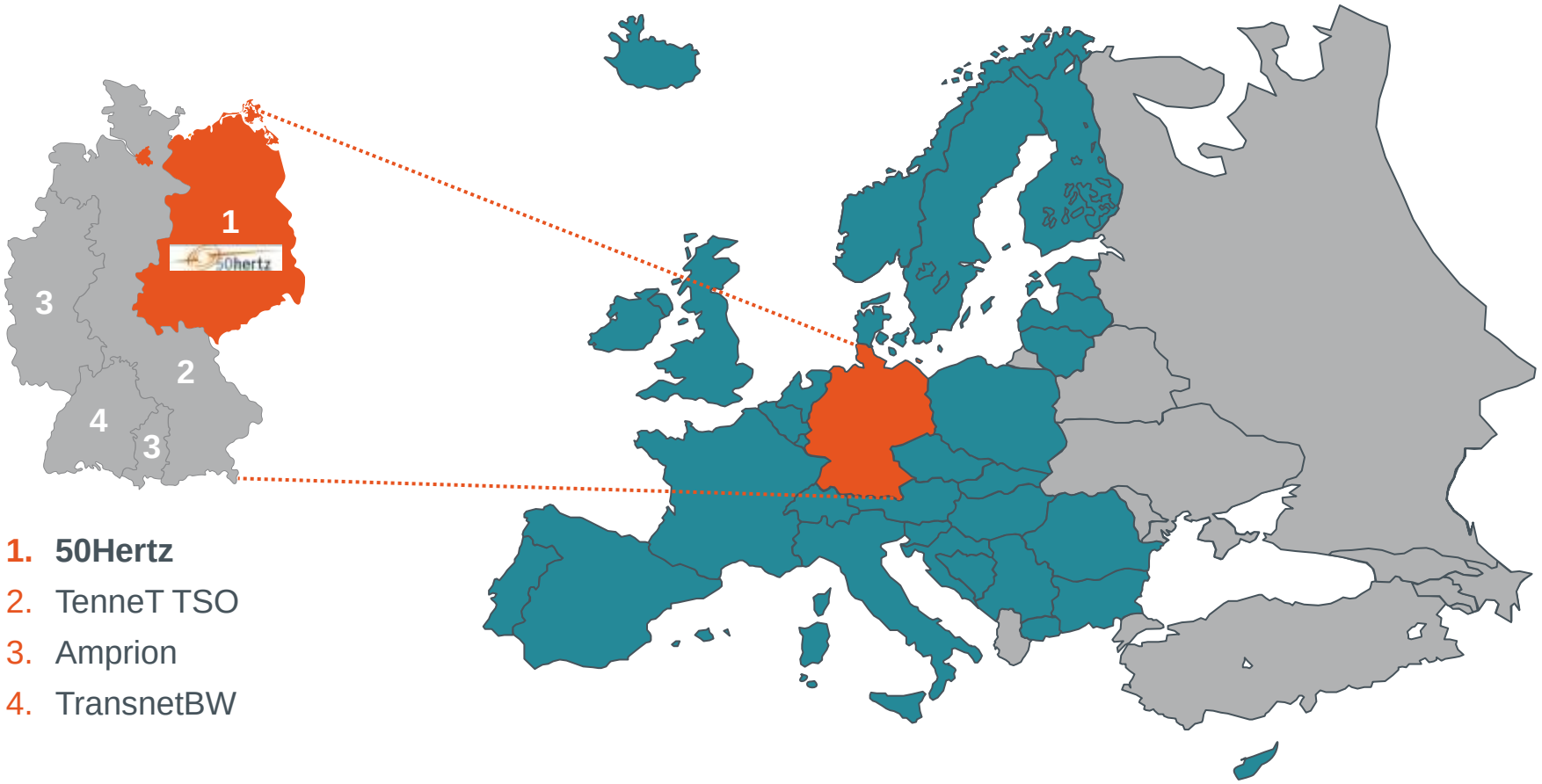
50Hertz as part of the European Electricity System



1. **50Hertz**
2. TenneT TSO
3. Amprion
4. TransnetBW

50Hertz at a glance

	2016	2010
Grid area	109.589 km² (~31 %)	109.360 km² (~31 %)
Length of lines	10.215 km (~30 %)	9.800 km (~30 %)
Max. Load	ca. 16 GW (~20%)	ca. 17 GW (~20 %)
Power consumption (based on electricity supplied to end-consumers in acc. with the EEG)	~ 96 TWh (~20 %)	ca. 98 TWh (~20 %)
Installed capacity: - of which Renewables - of which Wind	51.686 MW (~26%)* 28.435 MW (~30%)* 17.129 MW (~37%)*	38.354 MW (~35%) 15.491 MW (~30%) 11.318 MW (~40%)
RES share in power consumption	**47,8%**	ca. 25%
Turnover - of which grid	9,5 bln. € 1,3 bln. €	5,6 bln. € 0,6 bln. €

*Source: 50Hertz; As of 2016/12/31 - *preliminary figures – final figures will be available on 2017/08/31*

The German Energy Transition

What are the core elements of German „Energiewende“?

Policy-driven structural changes in the German energy system:

Phase out of nuclear energy production by 2022

Dynamic RES development (EEG 2.0)
Targets: 40-45% share of total electricity consumption until 2025, 80% until 2050

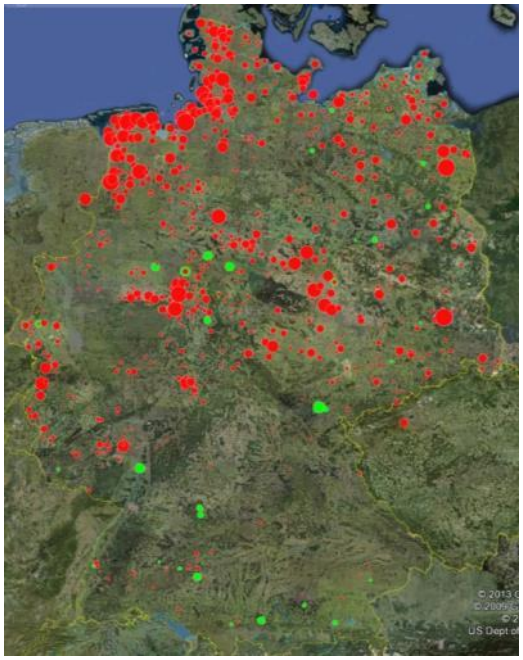
Greenhouse gas reduction: Future of coal-fired generation in question
Target: 40% CO_2 reduction by 2020, 80-95% by 2050

Energy efficiency: 50% increase of electricity efficiency by 2050

Grid extension to transport RES energy to the big industrial centres in Southern Germany

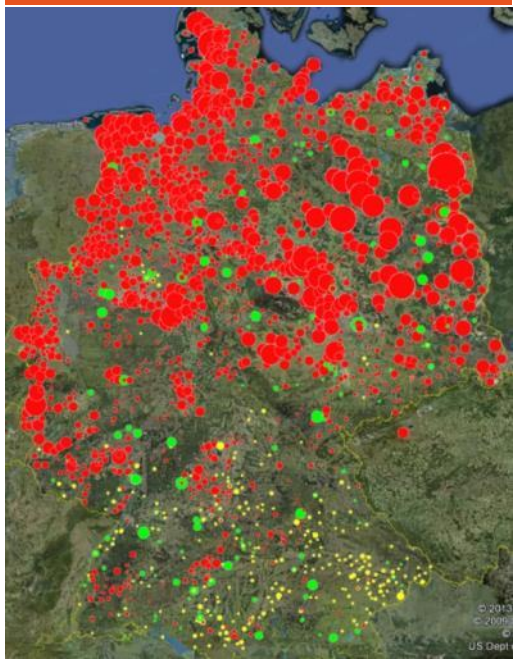
RES development in Germany

2000



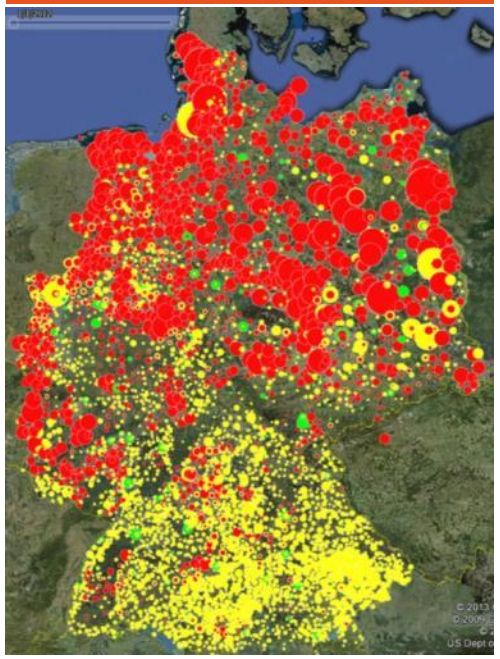
- ~ 30,000 plants
- 1.665* MW installed wind in Germany

2006



- ~ 221,000 plants
- 2.233* MW installed wind in Germany

2016



- ~ 1,600,000 plants
- 45.910* MW inst. wind

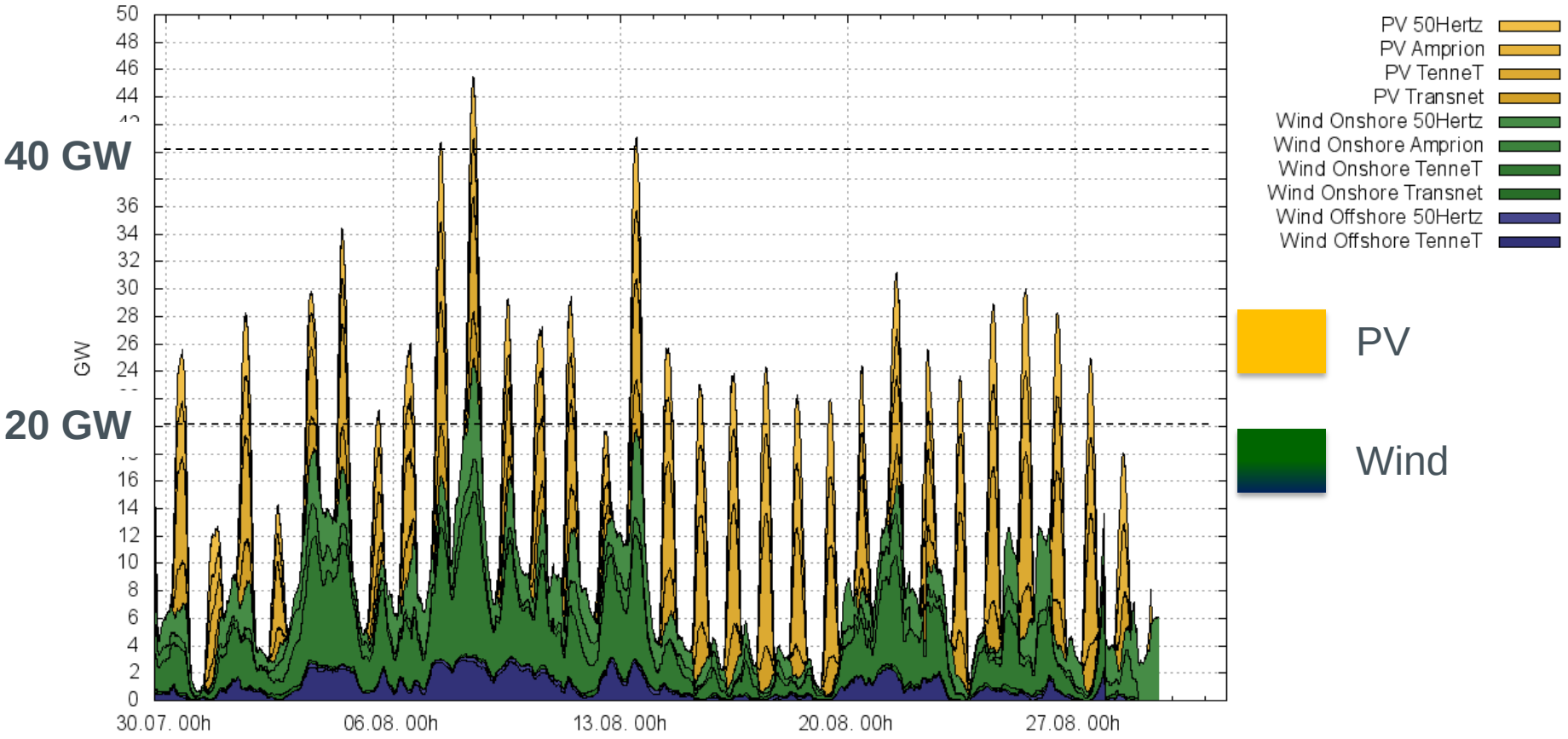
Massive RES growth in Germany since the introduction of the Renewables Energy Law (EEG) in 2000 – with Wind and PV as the main growth drivers

PV Wind Biomass

* BWE Figures

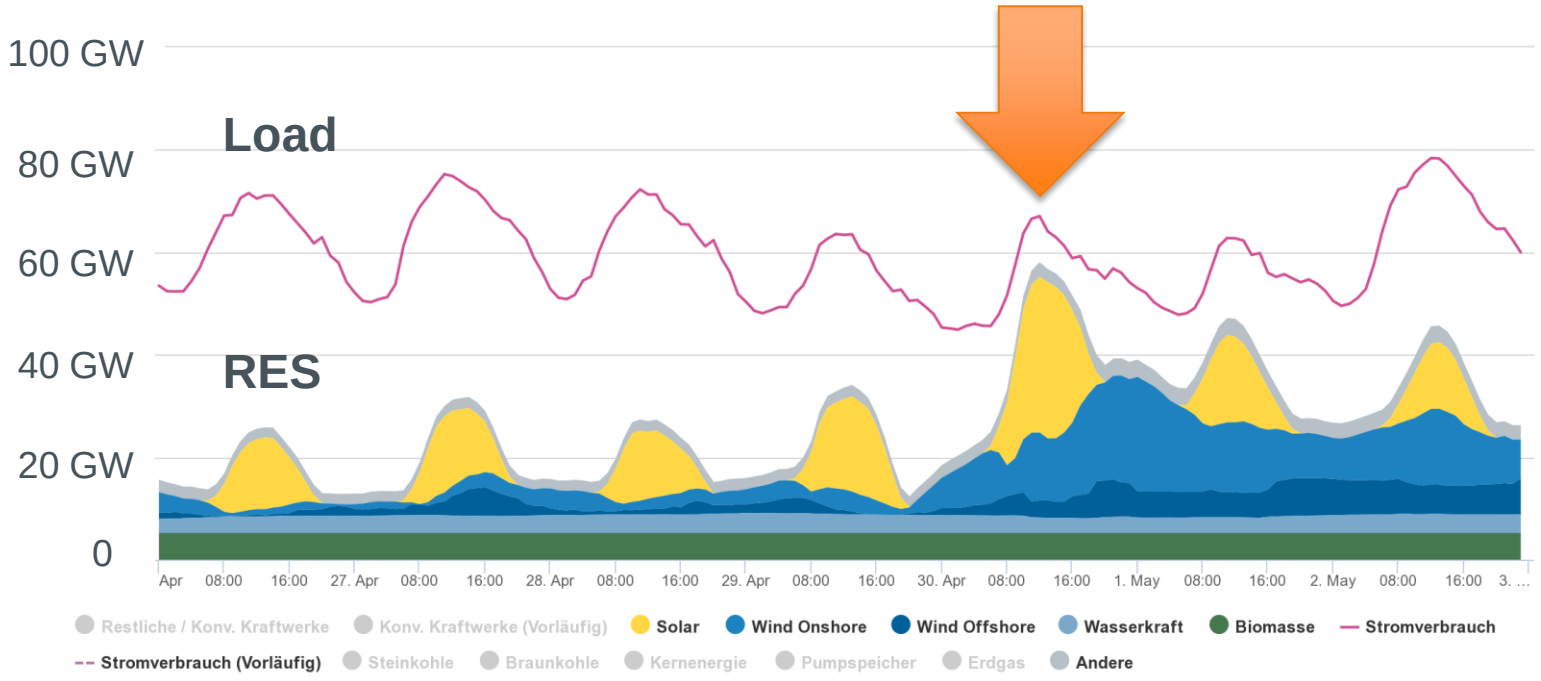
Source: 50Hertz, TenneT, Amprion, TransnetBW, Google Earth

RES infeed in Germany in August 2016



We encountered overlapping infeed of wind and PV of up to 50 GW

Renewable infeed in April 2017



Agora Energiewende; Stand: 29.05.2017, 23:10

On April 30th 2017 13-15h, 85% of the load in Germany were covered by RES (and the lights stayed on)

Contents

Elements of a successful energy transition

(or how to avoid mistakes we made)

1. Efficient RES support

- Volume control / Transparency
- Synchronization with grid infrastructure

2. Rights and responsibilities for RES

- Grid connection codes
- Active market participation
- Ancillary services from RES

3. Market design to accommodate for RES

- Balancing (in different timeframes)
- Congestion management
- Ancillary services from RES
- System adequacy

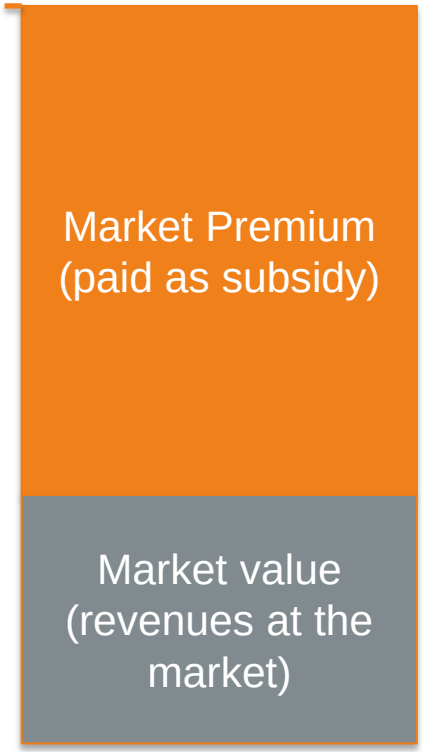
Grid connection codes

- In Germany, a major of RES installations had to be retrofitted in order to avoid sudden curtailment at a fixed over- or underfrequency (49,5 Hz or 50,2 Hz)
- Other important **grid connection requirements** include
  - Fault Ride Through Capability
  - Reactive power behaviour
  - Dynamic grid stabilization
  - Power Quality / Harmonics
- Grid connection codes are necessary for all generators and loads, not just RES and are needed to reflect physical realities!

By designing grid connection codes right for all market participants, large follow-up costs can be saved.

Handing over responsibility to RES generators - Market Premium Model

Former Feed-in tariff
(set by government/
Determined in tenders)

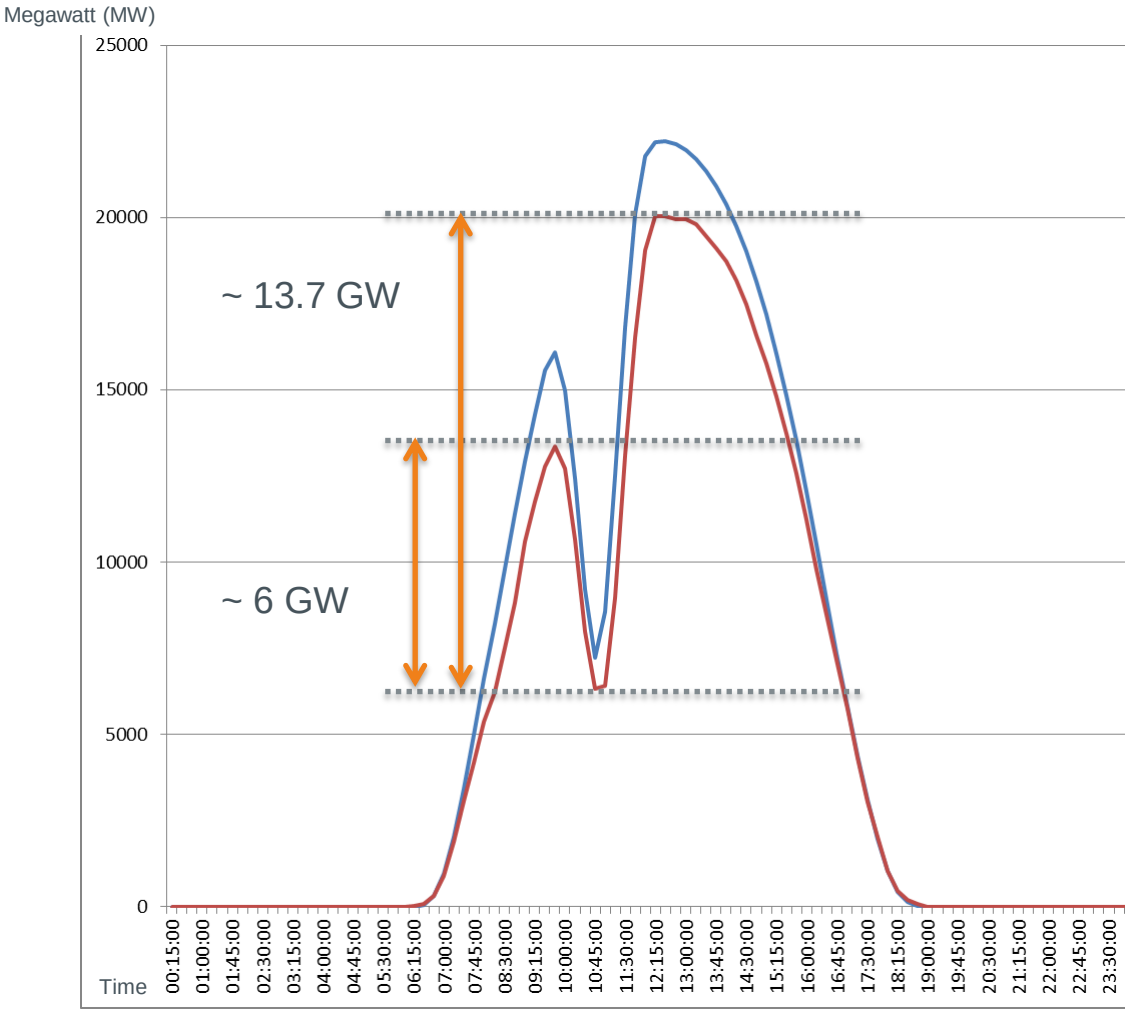


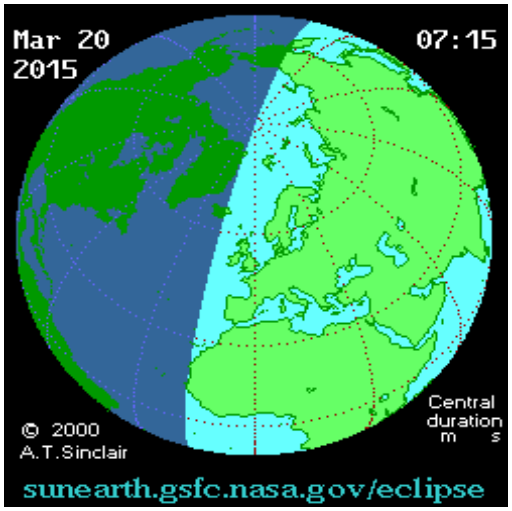
The market premium is calculated by the TSO as the difference of the „feed-in tariff“ and the market value

The market value is the weighted average wholesale price of an average generation profile (technology-specific monthly value)

With the incentives set right, market participants have proven capable of self-balancing their volatile RES portfolio

Solar eclipse 20th of March 2015: Successful system test





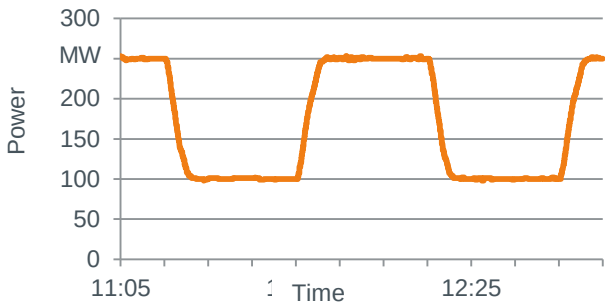
- **The market products that were developed and introduced over the last years worked properly.**
- **RES owners are able to manage their balancing groups themselves.**
- **Less demand for balancing by TSO**

PV-Kombi Germany, Day ahead Forecast 08.00 h
PV-Kombi, Germany, Extrapolation

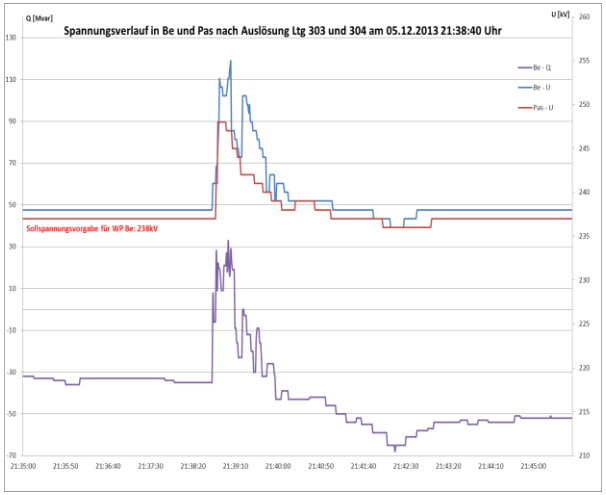
Ancillary services from RES

- Wind power plants are technically capable to provide balacing energy. **50Hertz is currently involved in pilot projects in Germany** to test this within the German market framework.
- Current challenges are the definition of the baseline and the design of the balancing market (daily tendering, hourly products….)
- Other pilot tests have shown that RES can contribute effectively to **stabilize the voltage** if faults occur in the system.
- Further pilot projects will even include **black-starting** a system with RES installations.

Demonstration-Test - balancing



Voltage stabilization by a wind farm



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Balancing the grid in different timeframes

RES volatility	Implemented solutions
Days to Hours	▪ New auctions for **strategic reserves** ▪ Contracting of **reserve power plants** ▪ *Capacity market if necessary*
Hours to Minutes	▪ International **market coupling** ▪ Introduction of a **liquid intraday market** ▪ Usage of **15-min products**
Minutes to Seconds	▪ **International imbalance netting** (*IGCC**) ▪ Allow new market participants in the balancing market (battery storages, loads, wind turbines) ▪ Dynamic allocation of balancing capacity

Grid Extension

**International Grid Control Cooperation*

Grid control cooperation – avoiding counteractive balancing

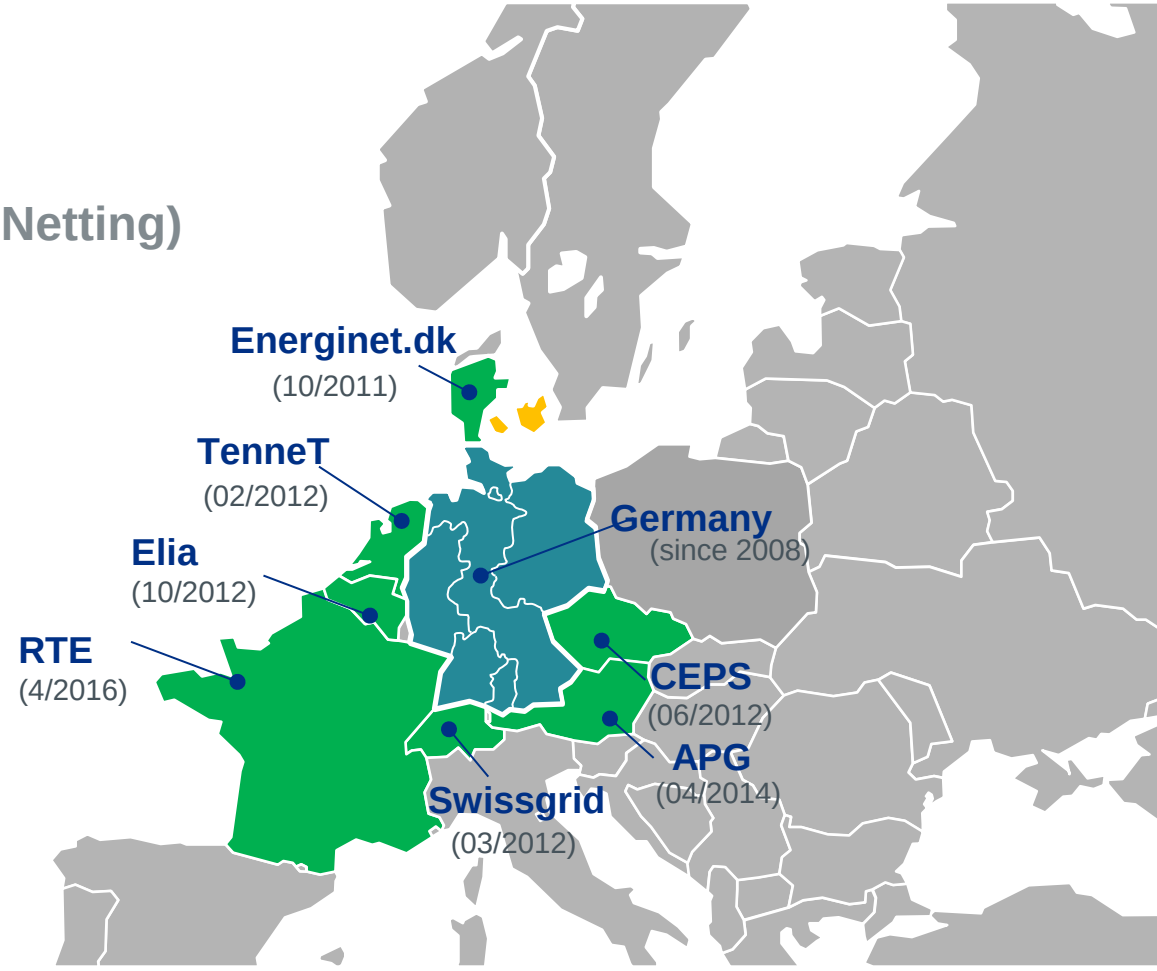
- National GCC (Module 1-4)
- IGCC (Module 1 Imbalance Netting)

Module 1 - IGCC:
Avoid Counteractivation

Module 2:
Common Dimensioning

Module 3:
Common Procurement of capacity

Module 4 – National GCC:
Activation based on common Merit Order List



The grid control cooperation helped to reduce the balancing demand significantly and saved already > 330 Mio. USD of balancing activations

New providers of control power are very welcome: Electric boilers and a steel mill prequalified in the 50Hertz control area

Electric boilers Stadtwerke Schwerin

- Three electric boilers prequalified for **secondary control** (aFRR) provision
- Up to **10 MW** aFRR
- Start of aFRR marketing in December **2013**

Steel mill Hamburg

- Electric furnace 3 of ArcelorMittal Hamburg GmbH prequalified for **tertiary control** provision (mFRR)
- Up to **70 MW** mFRR
- Start of mFRR marketing in **2010**

Sources: Stadtwerke Schwerin, ArcelorMittal Hamburg GmbH

Elements of a successful energy transition

1. **Efficient RES support and grid enforcement**

2. **Rights and responsibilities for RES**

3. **Market design to accommodate for RES**

There are challenges, but with right coordination, you can have green energy and high security of supply

Thank you for your attention!

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