The European Power System in 2030: Flexibility needs & integration benefits

Insights from an analysis with a Focus on the Central Western European power market

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PODGORICA, 17 NOVEMBER 2016
Starting point 1: Power systems shaped by wind & PV
Flexibility becomes the new paradigm of power systems

EU 2030: 50% RES-E, 30% Wind & PV in the overall generation mix

National energy strategies and scenarios in line with EU 2030 targets

Power generation CWE region (calendar week 32, 2030)*

* Weather data 2011

Fraunhofer IWES (2015)
Starting point 2: Regional cooperation becomes key

Central Western European power market / Pentalateral Energy Forum region

Regional approaches increasingly important to minimize total system costs and maximize system adequacy (and to achieve EU wide integration…)

Pentalateral Energy Forum (PLEF) / CWE important role model for the EU

Parallel “bottom-up” governance with larger / neighbouring regions (“12 electrical neighbours”, CEE, NSCOGI, CESEC,…)

Growing common understanding of medium and long-term challenges and no-regret ways forward
The Energiewende in a nutshell – with a focus on the power sector

Cross-border system integration
Minimising the flexibility challenge
Mitigating flexibility needs through market integration: Cross-border electricity flows enable geographical smoothing

Wind onshore generation in May 2030 at different levels of aggregation

**EU-wide aggregation**
Instantaneous total wind power output is much less volatile and lacks extremely high and low values

Largest EU-wide hourly wind ramp is -10% of installed capacity

For comparison, largest hourly wind ramp in France is 21% of installed capacity

*One pixel is equivalent to an area of 2.8 x 2.8 km*

Fraunhofer IWES (2015)

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Mitigating flexibility needs through market integration: Cross-border electricity flows enable geographical smoothing

Relative frequencies of hourly changes in onshore wind power output for the year 2030 at different levels of aggregation

**EU-wide aggregation**

Instantaneous total wind power output is much less volatile and lacks extremely high and low values

Largest EU-wide hourly wind ramp is -10% of installed capacity

For comparison, largest hourly wind ramp in France is 21% of installed capacity

EU-wide wind ramps larger +/-5% of inst. capacity in only 23hrs of the year

Fraunhofer IWES (2015)

* One pixel is equivalent to an area of 2.8 x 2.8 km
Seasonal weather patterns match monthly wind and PV generation yielding a more stable total renewables output

Monthly wind power and PV generation in Europe in 2030

Fraunhofer IWES (2015)

Weather year 2011
Market integration limits wind & PV curtailment (or storage needs) at times with high feed-in, increasing RES value

Curtailment of vRES within PLEF and Europe in autarchy and integration scenarios

- Curtailment is greatly reduced by market integration
- Curtailment in autarchy case is ten times higher due to lack of exchange options with other regions
- Not only cross-border grids are important, but also enough transfer capacities within countries must be available
- Still, avoiding curtailment altogether would be difficult to achieve just by increasing transfer capacities, as highly correlated feed-in situations can occur

Fraunhofer IWES (2015)
Market integration allows dealing with domestic deficits and surpluses: Each country is sometimes importer / exporter

Exports and imports of the PLEF / CWE countries in 2030

Fraunhofer IWES (2015)
The “remaining” flexibility challenge
(after market integration)
We need a flexible power system to manage remaining ramps from variable renewable energies

Power generation in the PLEF/CWE* region in a week in 2030 with high vRES (calendar week 32)

Fraunhofer IWES (2015)

*AT, BE, CH, DE, FR, LU, NL
Net load* will show steeper ramps, baseload needs reduce significantly

(Residual) load in PLEF/CWE region (calendar week 32 - 2030)

Important flexibility options

- Grids (domestic & cross-border) ➔ enabling smoothing effect

- Partial curtailment of wind and solar power

- Flexible fossil and biomass plants (incl. CHP with heat storage & Power-to-Heat)

- Demand Side Management

- Storage (Hydro; Batteries)
  Integrating sectors ("Power-to-X")

Fraunhofer IWES (2015) *Load minus non-dispatchable renewables
We need a flexible power system to provide backup capacity for longer periods with little vRES feed-in

Power generation in the PLEF/CWE* region in a week in 2030 with little vRES (calendar week 3)

Fraunhofer IWES (2015) *AT, BE, CH, DE, FR, LU, NL
The need for baseload power plants is significantly reduced by 2030

Load duration curve, duration curve of generation of residual power plant park for PLEF/CWE* 2030

50% RES-E in the EU’s power system (~30% wind and PV (~2030)) reduce capacity needs for power plants running more than 7000hrs per year by 50%

Agora Energiewende based on Fraunhofer IWES (2015) *AT, BE, CH, DE, FR, LU, NL; Weather year 2011
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Peak load needs are reduced less strongly

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Agora Energiewende based on Fraunhofer IWES (2015) *AT, BE, CH, DE, FR, LU, NL; Weather year 2011
Net load pattern reduces residual power plant park & changes structure: Fewer baseload, more mid-merit & peaking capacity

Structure* of the residual power plant park in Germany in 2013 and 2030 for the integration scenario

Agora Energiewende based on Fraunhofer IWES (2015) *The structure is derived from assumed capacity factor (CF) values: Plants with a capacity factor of 80% or larger (>7000 full load hours), a capacity factor between 20% and 80% (1750-7000 full load hours) and a capacity factor smaller than 20% (<1750 full load hours) are shown.
Flexibility Challenges and Integration Benefits:
Main takeaways

- As wind & PV will shape EU power systems (2030 share ~30%), increasing **system flexibility** is **crucial**
- **Power system & market integration** mitigates flexibility needs due to smoothing effects. Hourly wind **ramps decrease by ~50%** comparing the national and European scale
  - Integration yields **reduced gradients of residual load, reduced balancing requirements**
  - Integration **minimises renewables curtailment by 90%**
- **System adequacy**: Regional peak load is smaller than sum of national peak loads ➔ fewer installed capacities required
- Still, a **more flexible power system is required**
  - The structure of the conventional power plant park and the way power plants operate will need to change: **Less baseload, relatively more mid-merit and peak-load plants**
  - An **active demand side**, an **adjusted power plant park** and **storage** will manage the flexibility challenge
- Flexibility potential is large, its development requires proactive policies ➔ **Refined market design** that stresses system flexibility
Thank you for your attention!

Questions or Comments? Feel free to contact me:
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Agora Energiewende is a joint initiative of the Mercator Foundation and the European Climate Foundation.
Flexibility, security of supply & market design
A no-regret way forward: A refined EOM which eliminates flexibility barriers, incentivises flexibility & enables RES-E market integration

→ Cross-border cooperation regarding security of supply & market design “no-regret” for all
  → Resource adequacy should be assessed on regional level
  → Capability (quality of capacity) rather than (quantity of) capacity critical for CRM design
    → Resource adequacy is not only about “how much?”, but also about “what kind?”
→ Strong price signals are required to manage the complexity efficiently
  → **Faster** day-ahead, intraday and balancing energy markets: From hourly to quarterly
  → **Coupled** short-term markets: Integrate across balancing areas
  → **Link** spot market, balancing market and imbalance price signals
  → **Minimise** fossil must-run
    → Smart balancing energy products (and procurement); RES-E, DSR as new service providers
    → **Minimise** inflexible fossil capacity ➔ **Smart retirement policies**
→ **Spot** price as undistorted dispatch signal for all market parties

Source: RAP (2014)