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South-East Europe Electricity Roadmap

Agora Energiewende

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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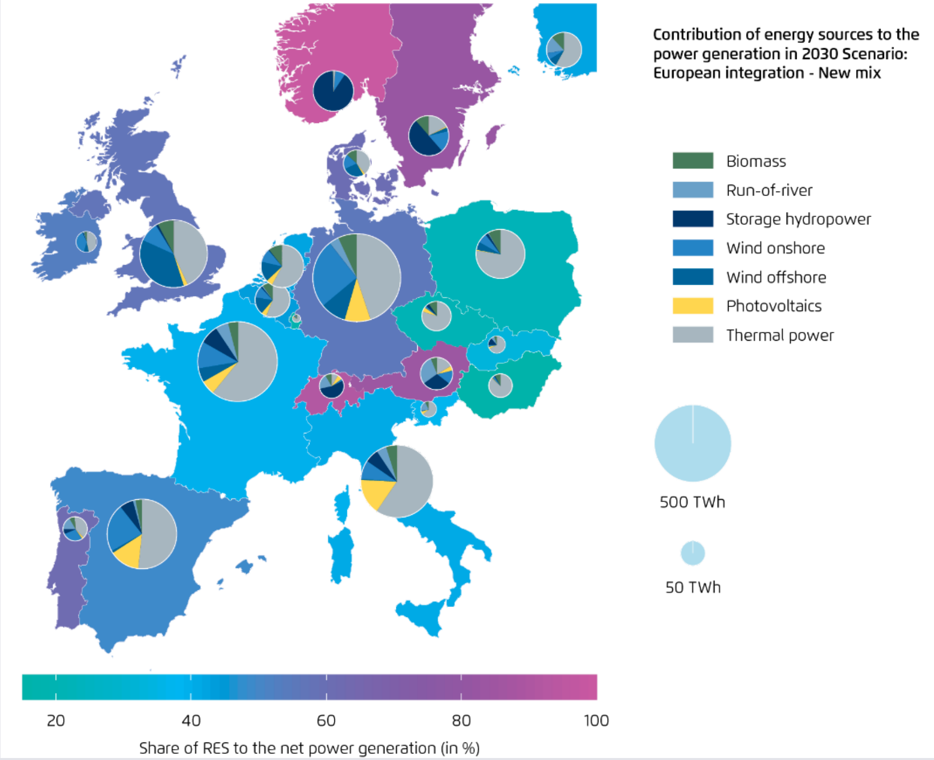
SOFIA, 17 JANUARY 2017

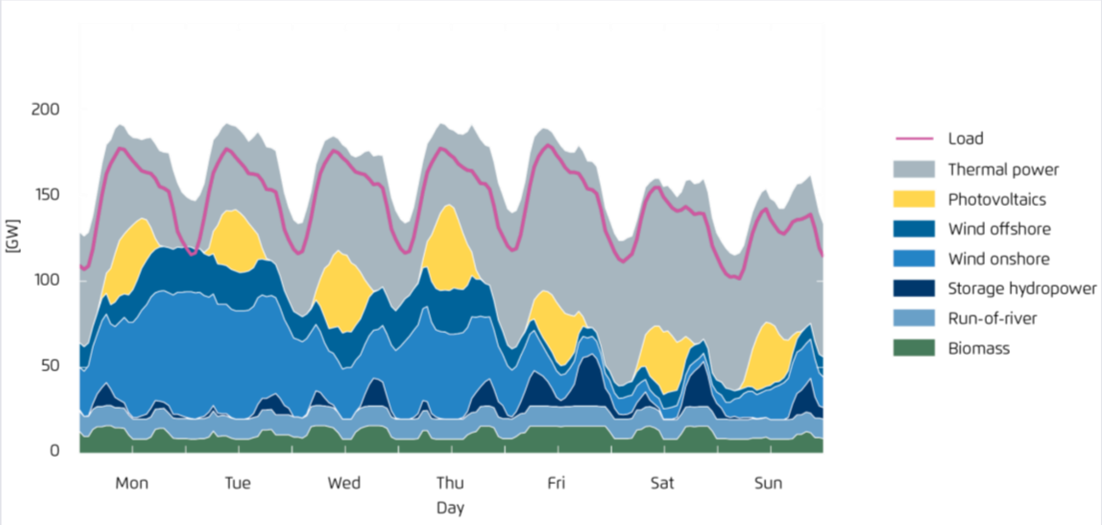
Starting point 1: Power systems shaped by wind & PV
Flexibility becomes the new paradigm of power systems

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)*



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* Weather data 2011

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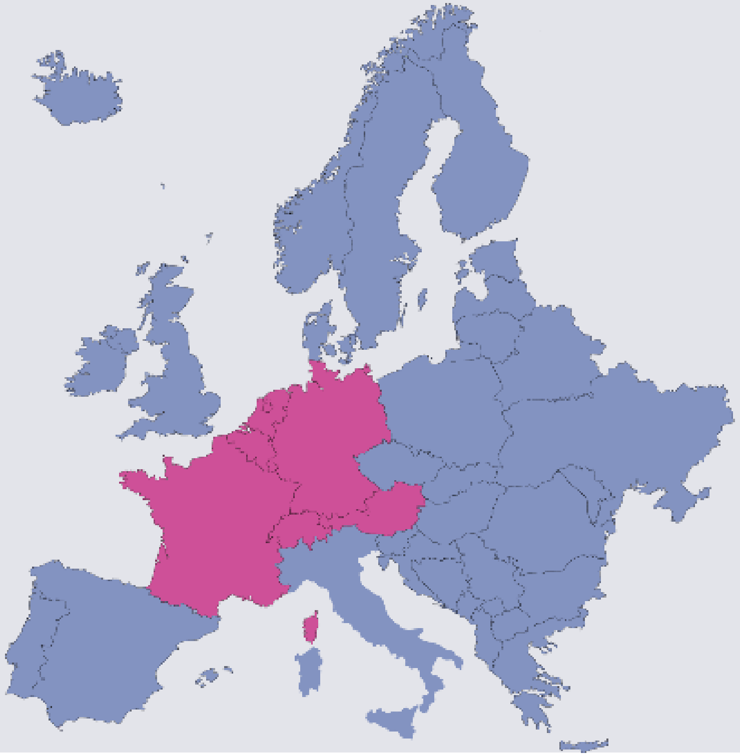
Starting point 2: Regional cooperation becomes key

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

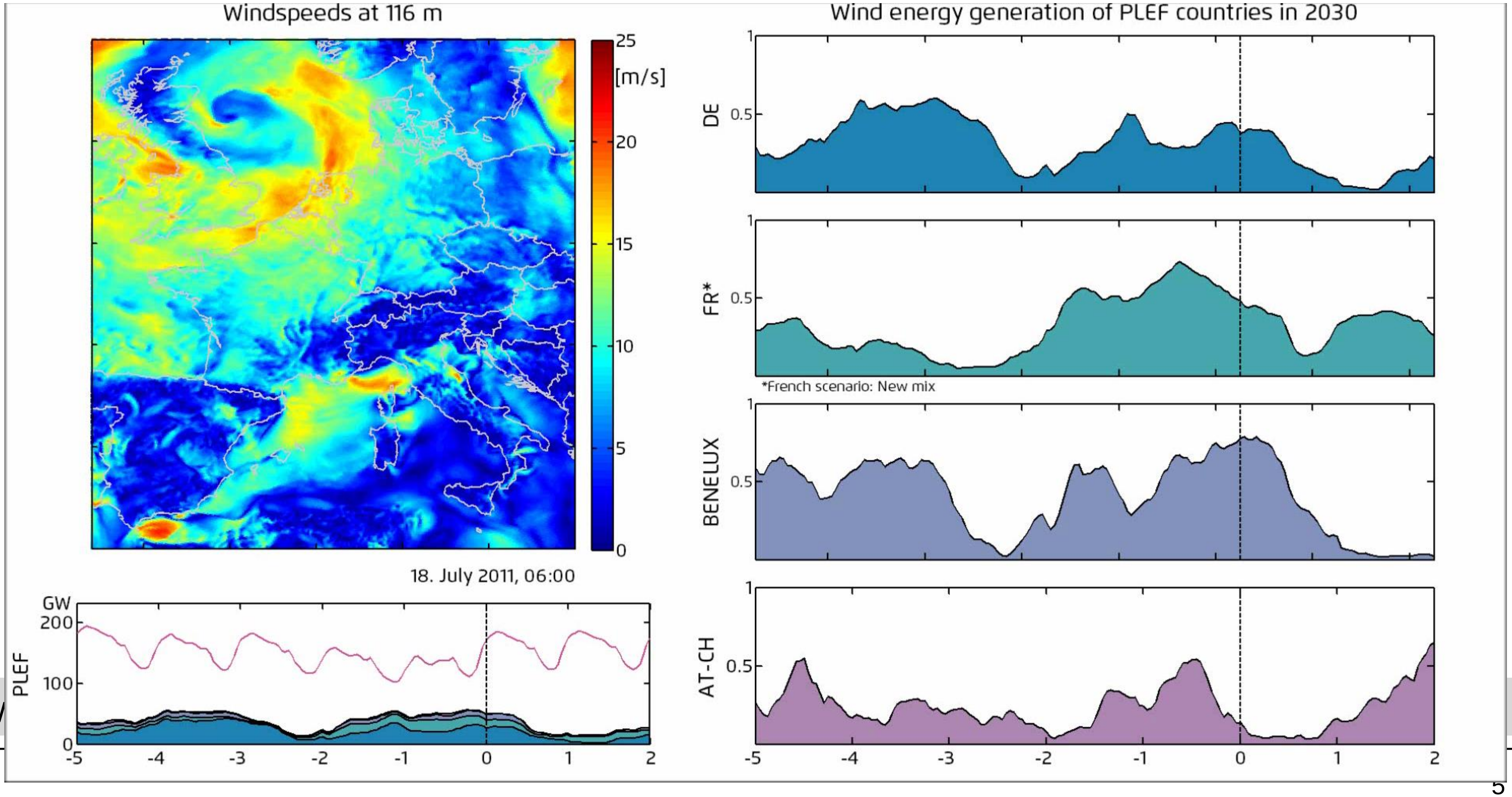
Parallel “bottom-up” governance with larger / neighbouring regions (“12 electrical neighbours”, CEE, NSCOGI, CESEC,…)

Growing common understanding of medium and long-term challenges and no-regret ways forward

Cross-border system integration

Minimising the flexibility challenge

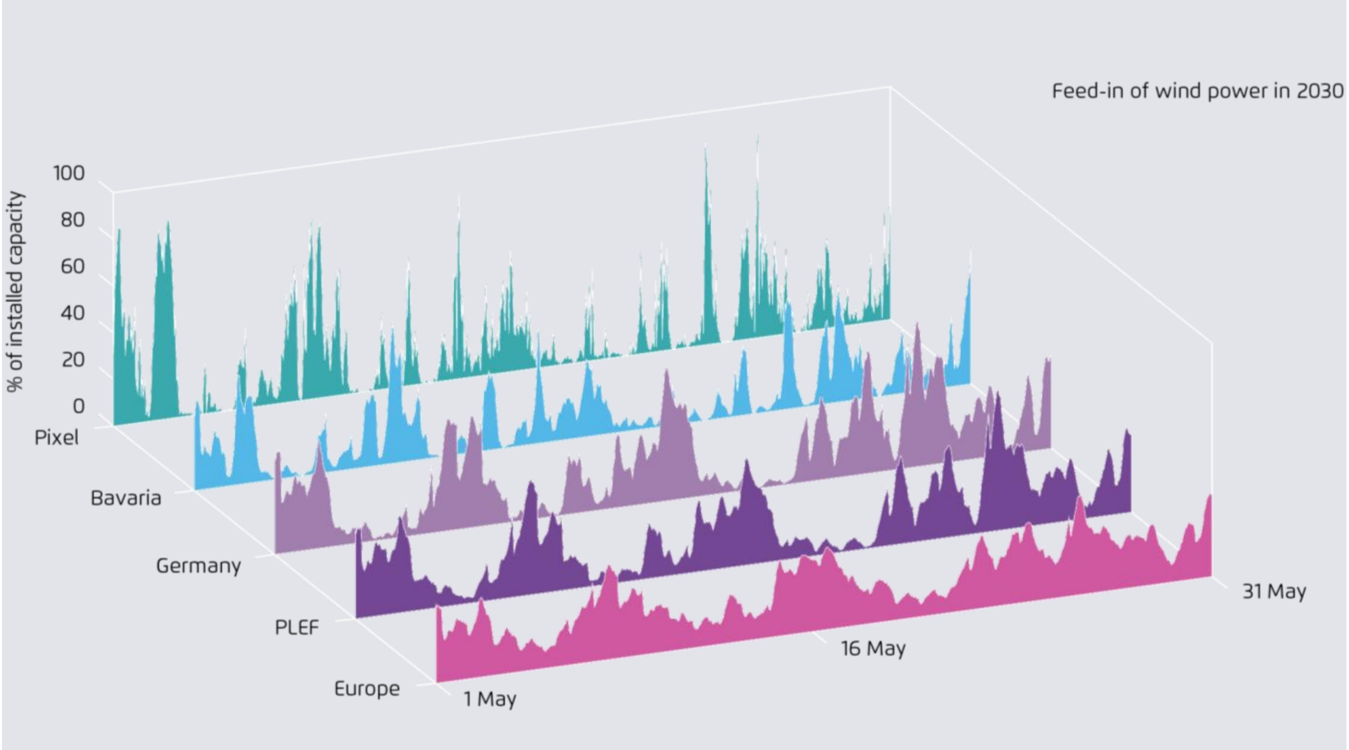
As wind power and solar PV are weather-depend generation is fluctuating and flexibility requirements increase.
Yet, coupling power systems helps



Fraunhofer IW

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

Wind onshore generation in May 2030 at different levels of aggregation



Fraunhofer IWES (2015)

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

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

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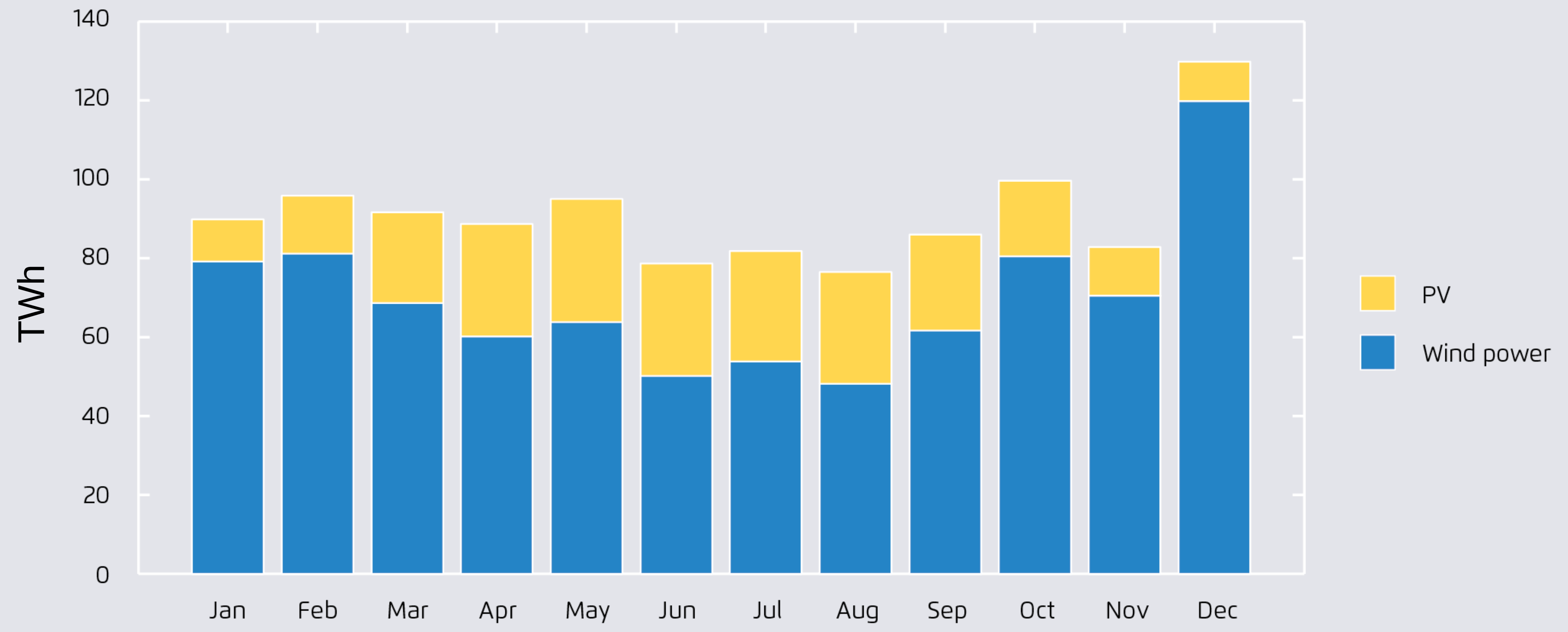
Seasonal weather patterns match monthly wind and PV generation yielding a more stable total renewables output

Monthly wind power and PV generation in Europe in 2030



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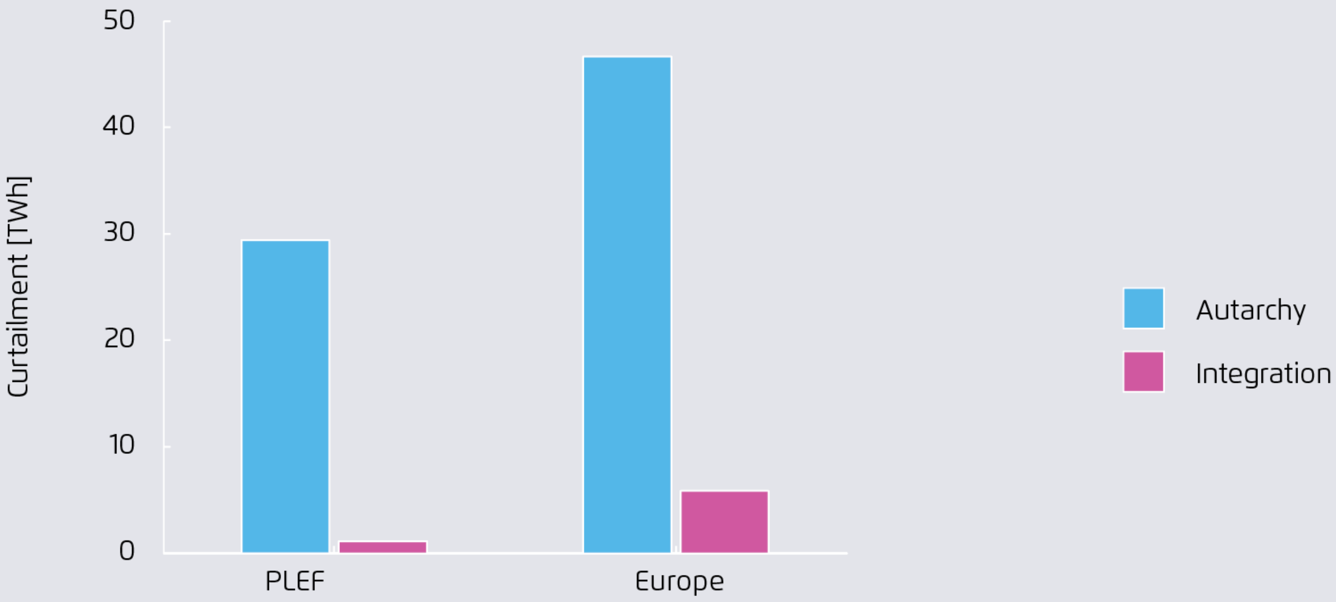
Weather year 2011

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



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Curtailment is <u>greatly reduced by market integration</u>

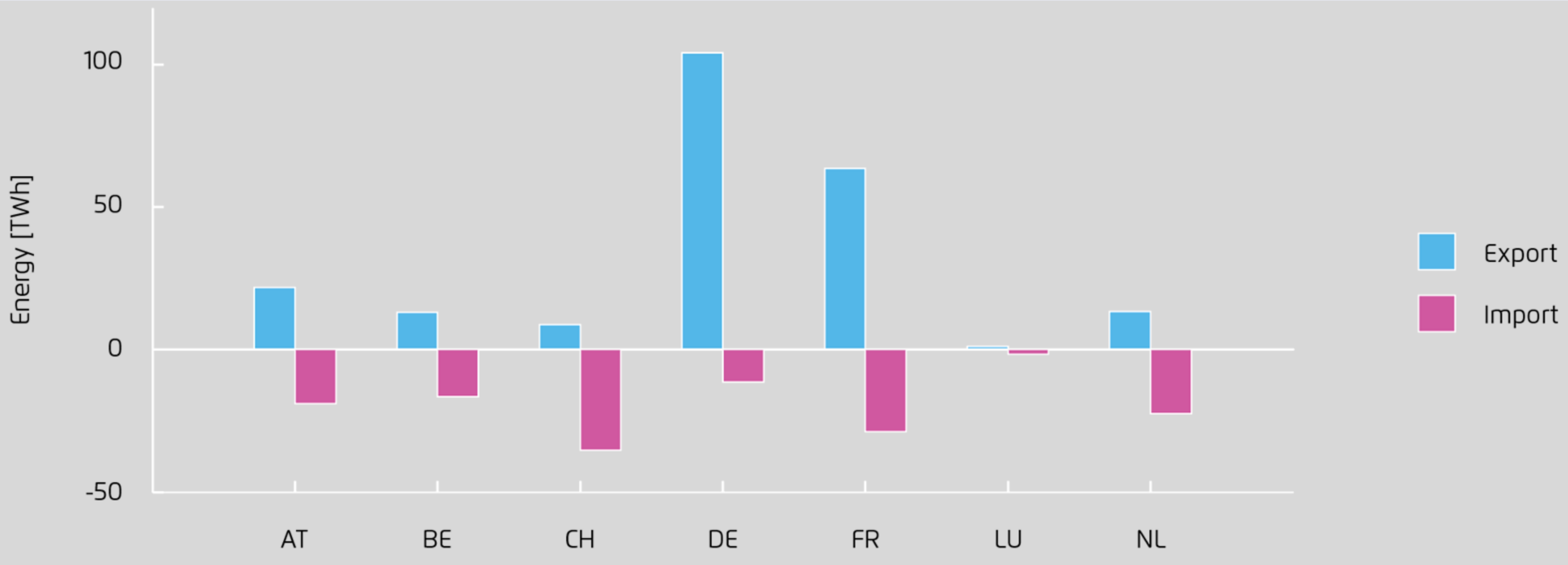
Curtailment in autarchy case is <u>ten times</u> higher due to lack of exchange options with other regions

Not only <u>cross-border grids</u> are important, but also <u>enough transfer capacities within countries must be available</u>

Still, avoiding curtailment altogether would be difficult to achieve just by increasing transfer capacities, as <u>highly correlated feed-in situations can occur</u>

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



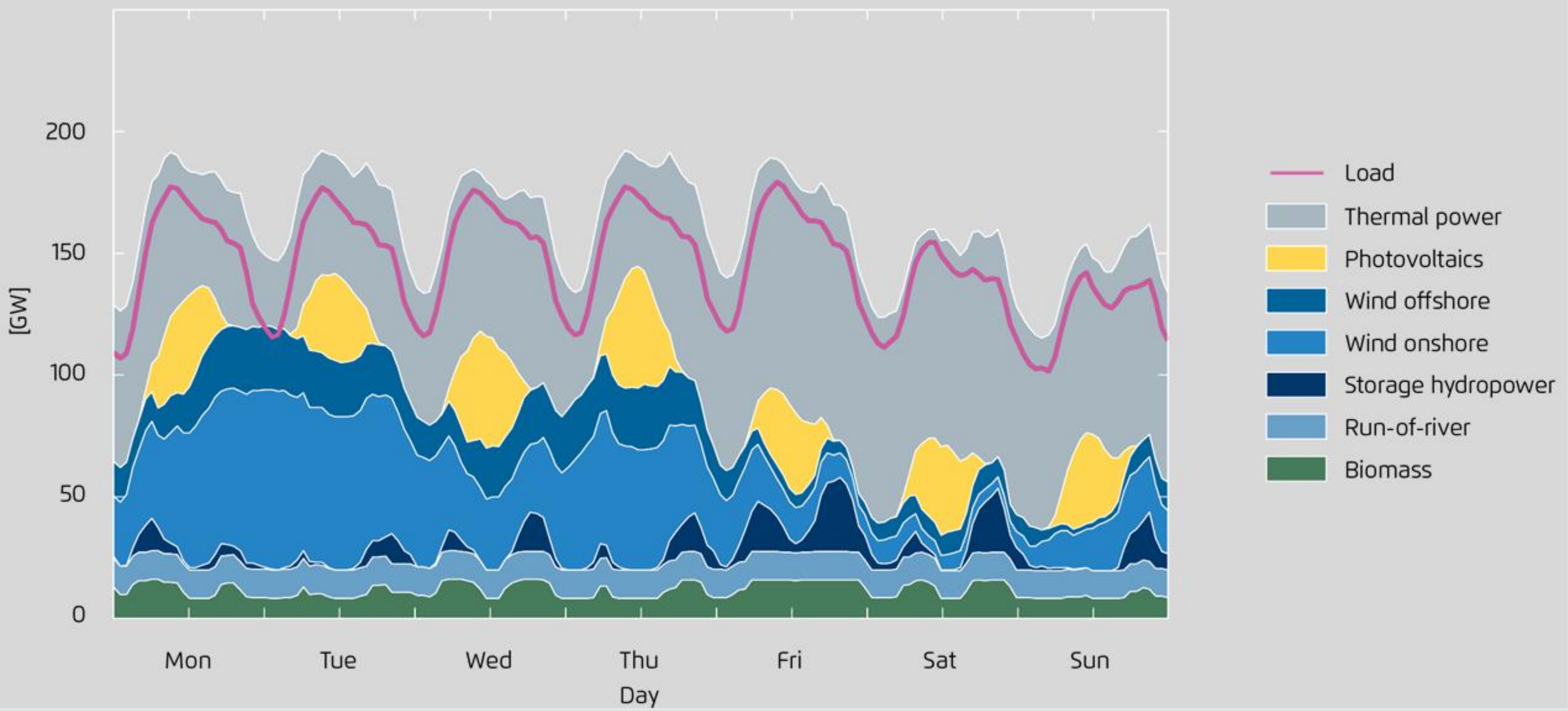
Fraunhofer IWES (2015)

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)



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*AT, BE, CH, DE, FR, LU, NL

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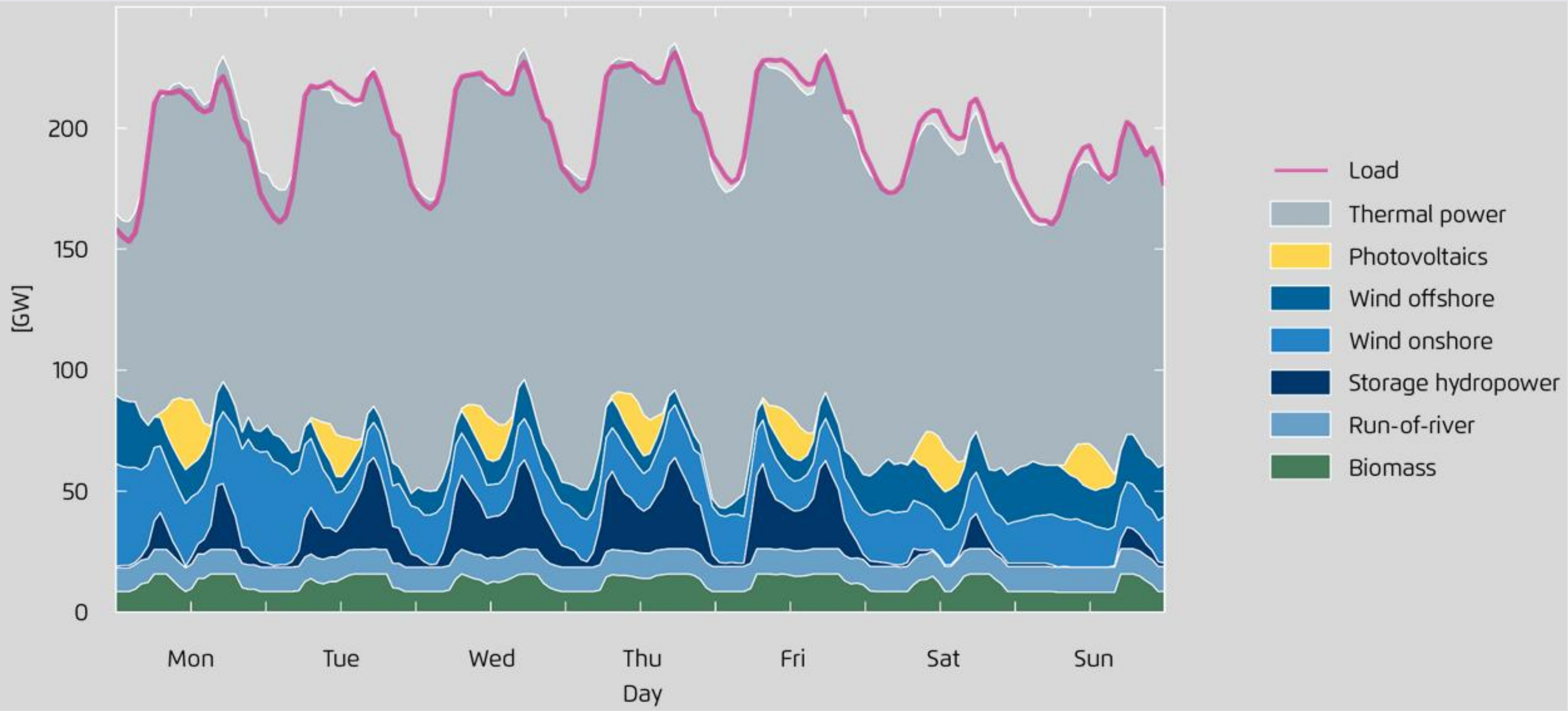
We need a flexible power system to provide backup capacity for longer periods with little vRES feed-in

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



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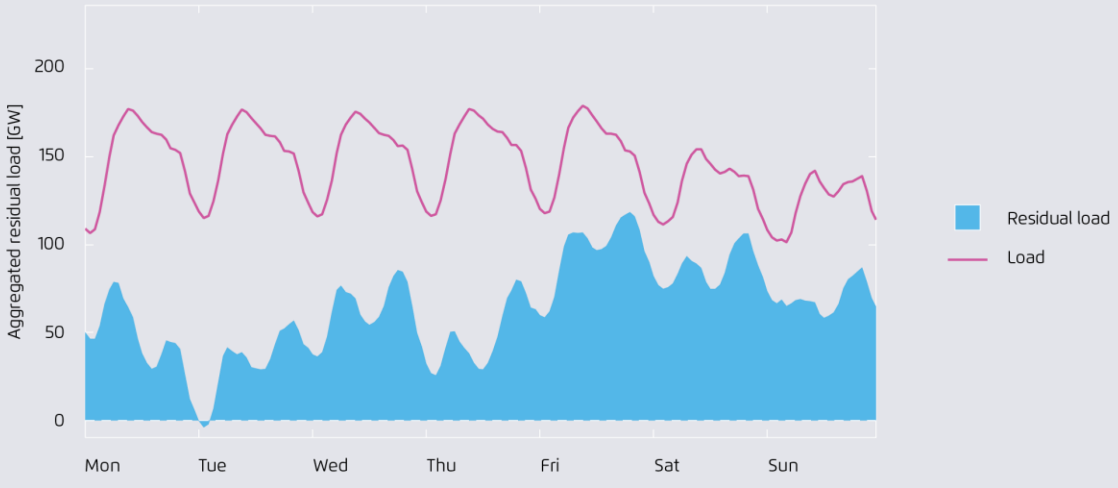
*AT, BE, CH, DE, FR, LU, NL

Net load* will show steeper ramps, baseload needs reduce significantly

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

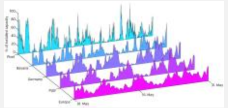


Fraunhofer IWES (2015)

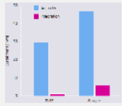
*Load minus non-dispatchable renewables

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)

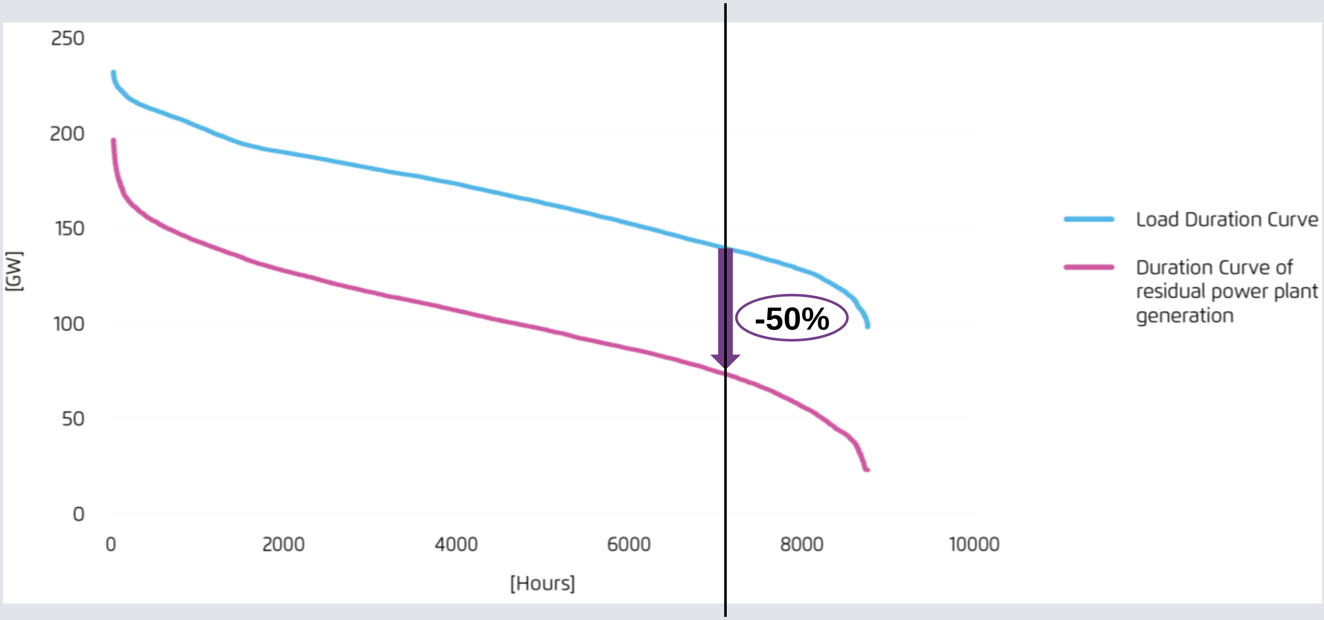
Focus in the following

Demand Side Management

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

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



Agora Energiewende based on Fraunhofer IWES (2015) *AT, BE, CH, DE, FR, LU, NL; Weather year 2011

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%

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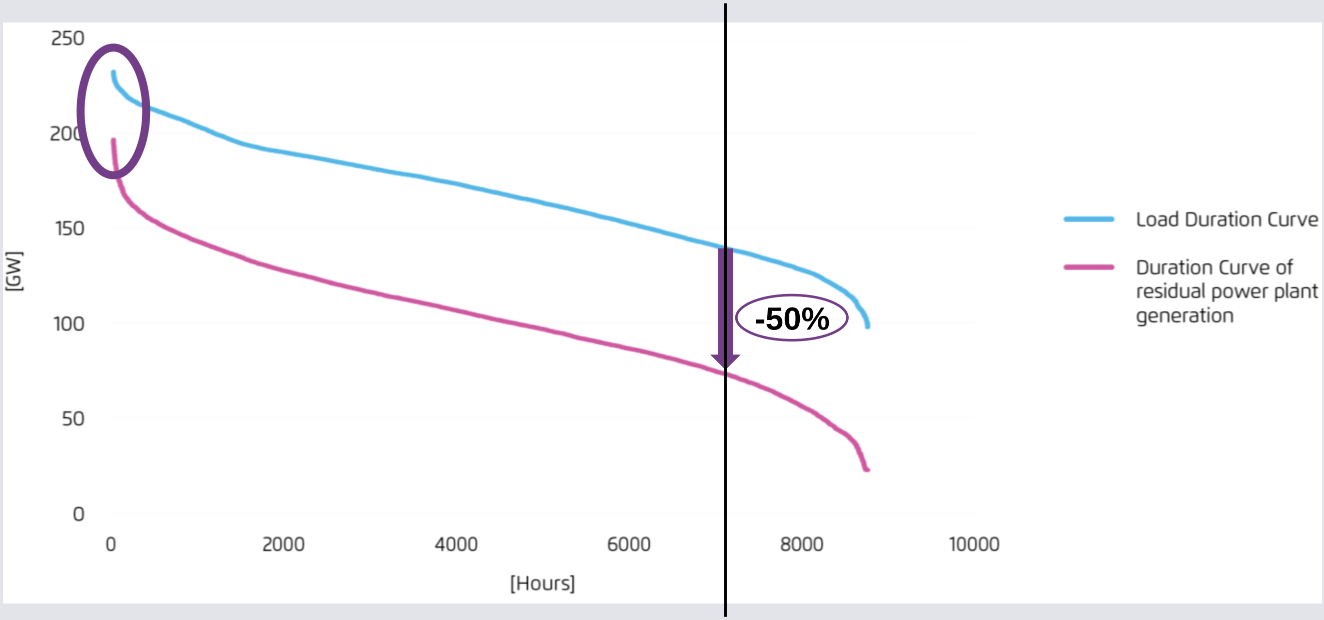

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Peak load needs are reduced less strongly

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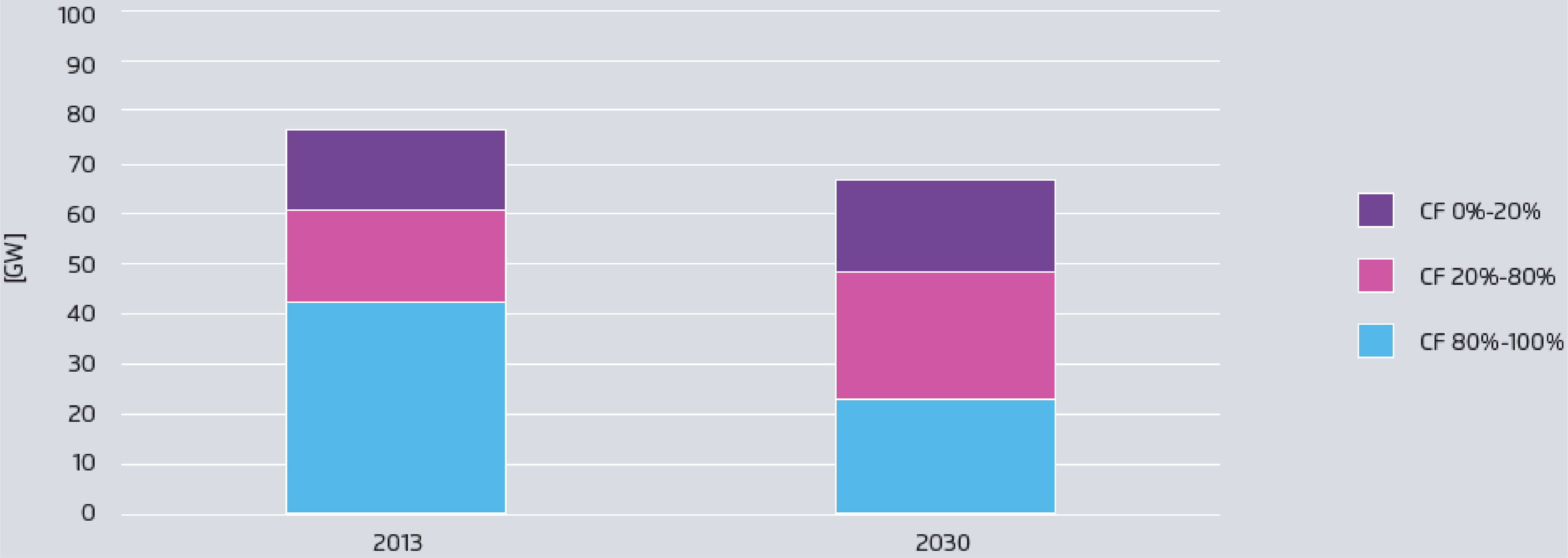
Net load pattern reduces residual power plant park & changes structure: Fewer baseload, more mid-merit & peaking capacity

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.

Security of supply: Regional peak load is smaller than sum of national peak loads ➔ fewer installed capacities required

Correlation coefficients (based on Kendall's tau rank) between PLEF countries for load

Load	AT	BE	CH	DE	FR	LU	NL
AT	100%	72%	57%	82%	57%	57%	74%
BE	72%	100%	63%	73%	66%	57%	70%
CH	57%	63%	100%	54%	73%	43%	48%
DE	82%	73%	54%	100%	52%	61%	77%
FR	57%	66%	73%	52%	100%	43%	49%
LU	57%	57%	43%	61%	43%	100%	54%
NL	74%	70%	48%	77%	49%	54%	100%

Fraunhofer IWES (2015)

Based on weather year 2011

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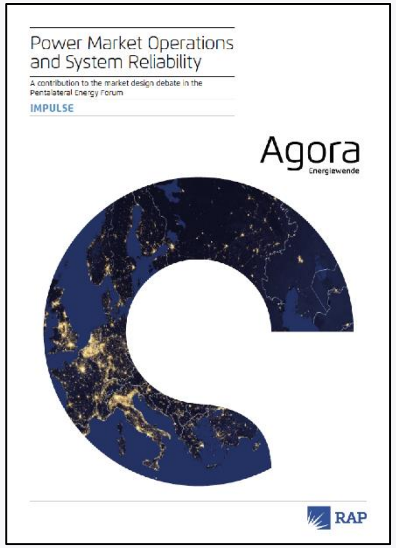
Flexibility Challenges and Integration Benefits: Main takeaways

- 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

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)

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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.

Weather patterns are not perfectly correlated across Europe: This yields smoothing effects especially for wind generation (and also load…)

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Correlation coefficients (based on Kendall's tau rank) between PLEF countries for wind onshore generation

Wind	AT	BE	CH	DE	FR	LU	NL
AT	100%	24%	45%	35%	27%	29%	22%
BE	24%	100%	27%	49%	55%	66%	60%
CH	45%	27%	100%	28%	39%	32%	22%
DE	35%	49%	28%	100%	33%	47%	58%
FR	27%	55%	39%	33%	100%	52%	34%
LU	29%	66%	32%	47%	52%	100%	44%
NL	22%	60%	22%	58%	34%	44%	100%

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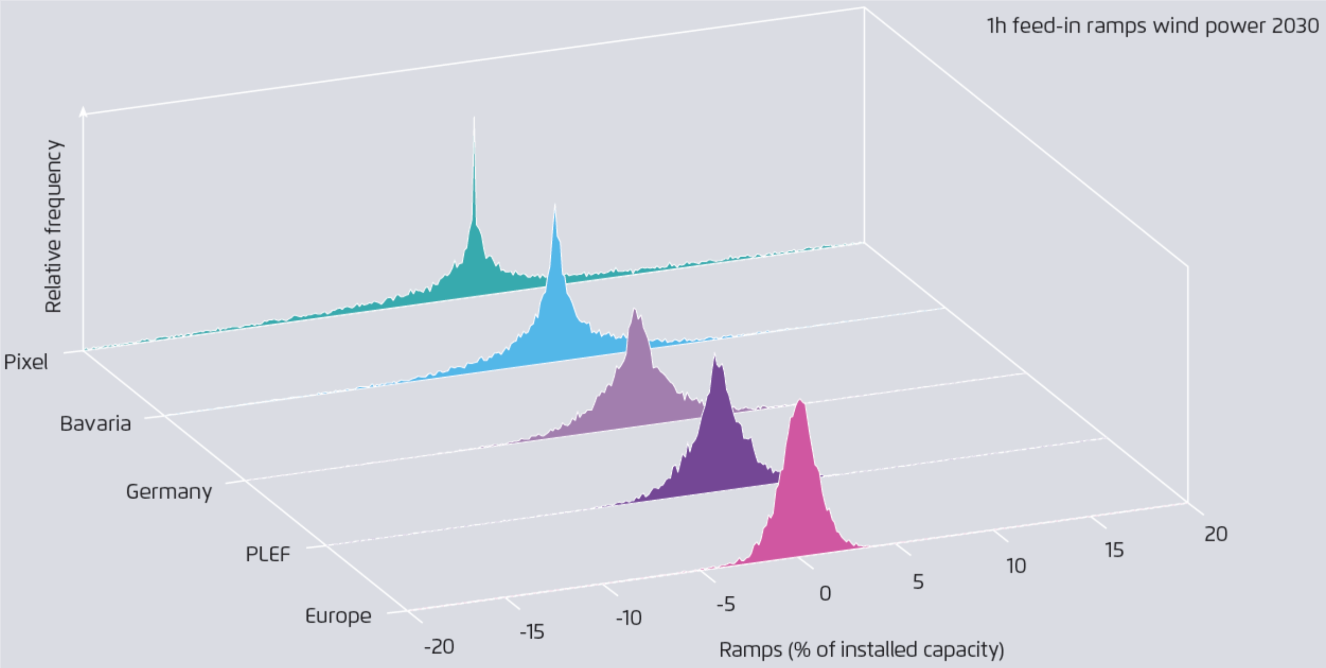
Relative frequencies of hourly changes in onshore wind power output for the year 2030 at different levels of aggregation



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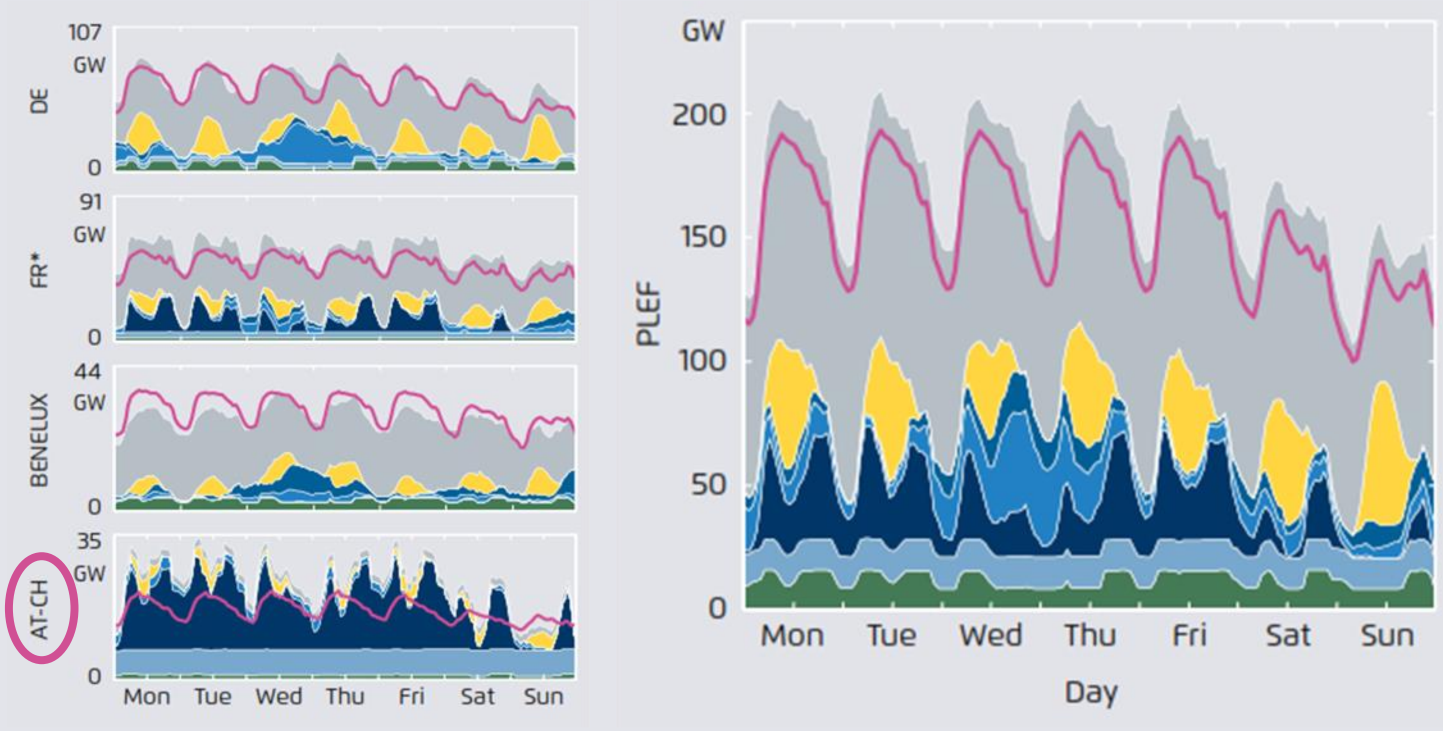
For comparison, largest hourly wind ramp in France is 21% of installed capacity

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

Flexible hydro (pumped) storage a "constant" for flexibility provision

Electricity generation and consumption in Central-Western Europe* in calendar week 23 (high share of wind & PV) in 2030

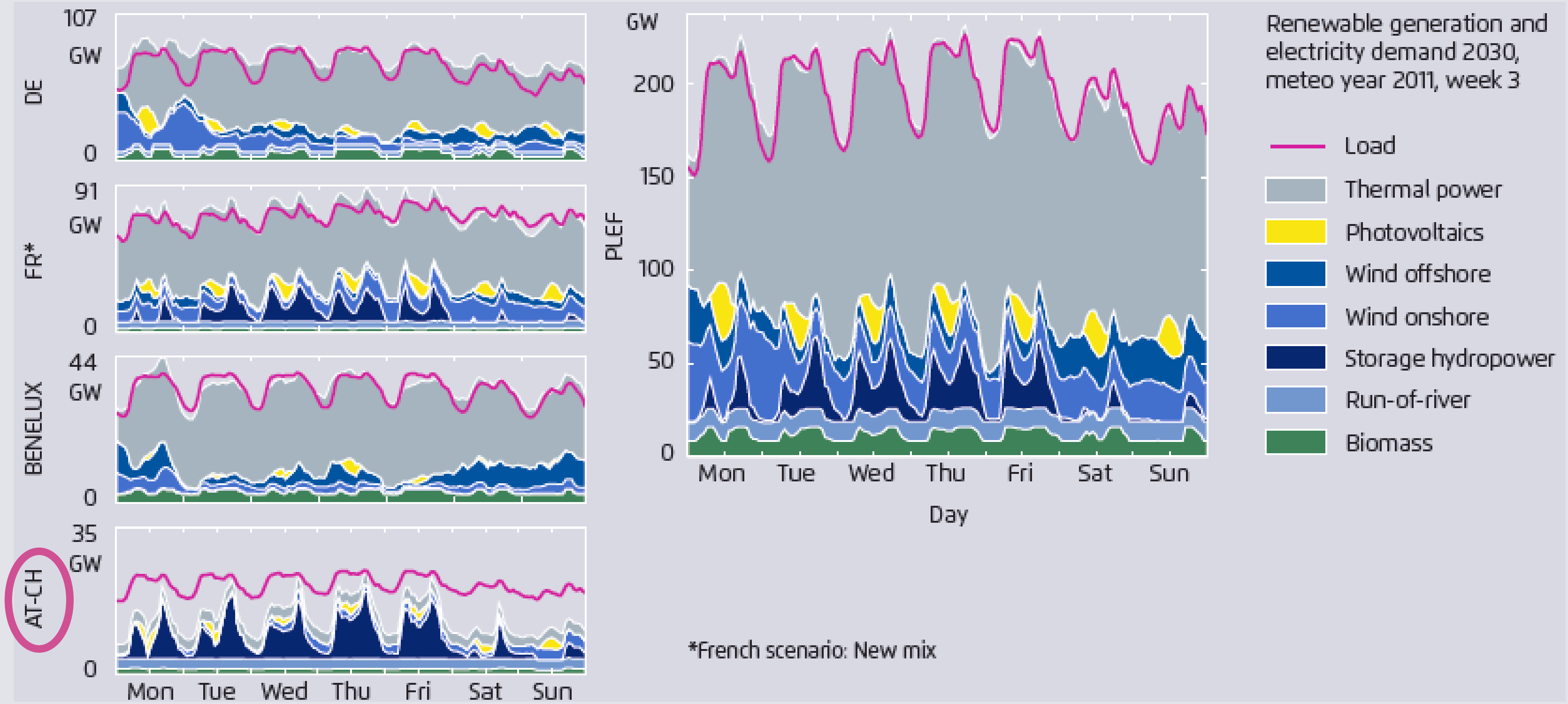


Fraunhofer IWES (2015)

* Germany, France, Benelux, Austria, Switzerland

Flexible hydro (pumped) storage a “constant” for flexibility provision

Electricity generation and consumption in Central-Western Europe* in calendar week 3 (low share of wind & PV) in 2030



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