ProPower: A new tool to assess the value of probabilistic forecasts in power systems management

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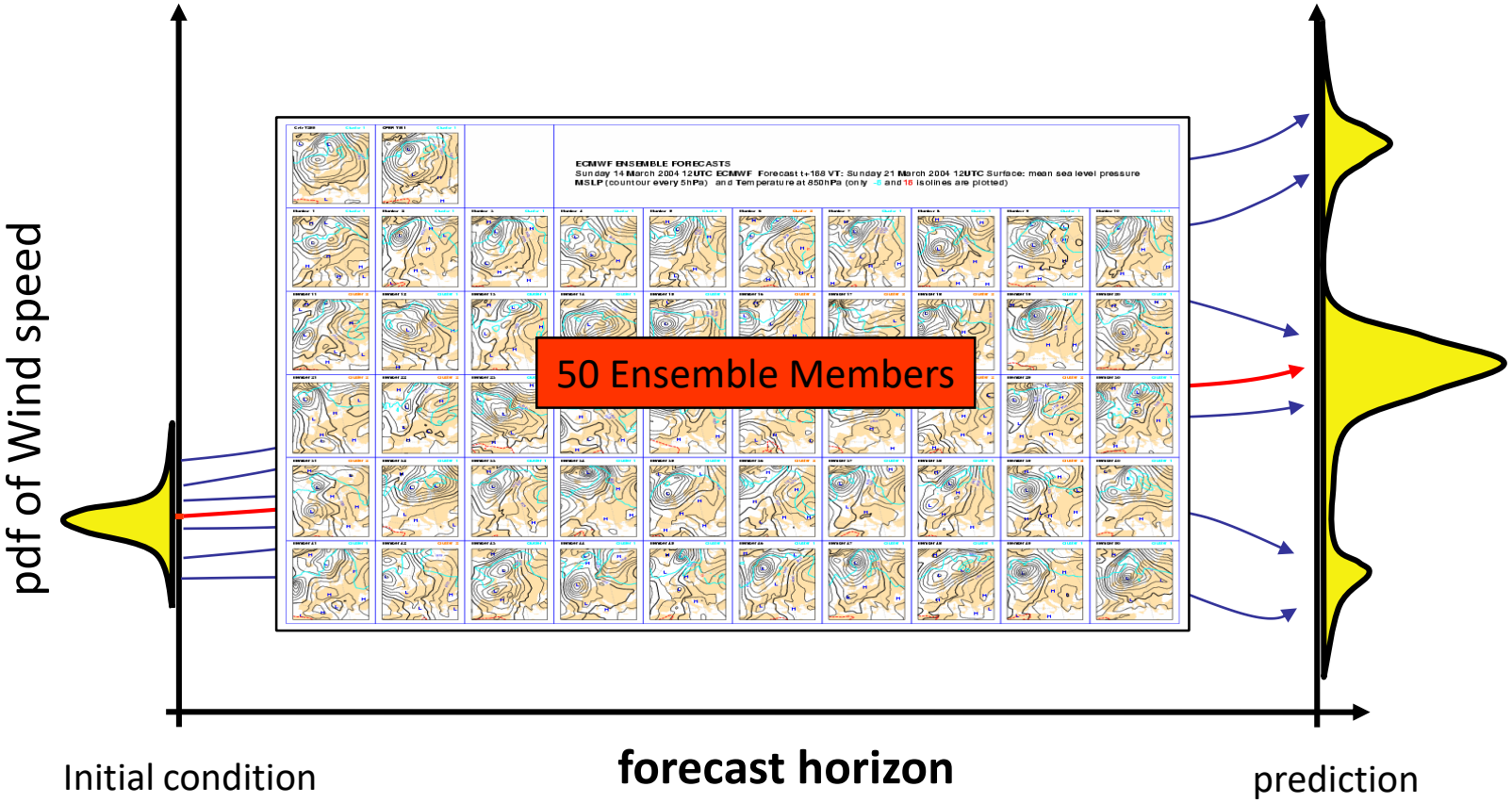
Annual EMS Meeting 2024, Barcelona & online

DLR

What is the potential value of Ensemble Forecasting in RES integration?



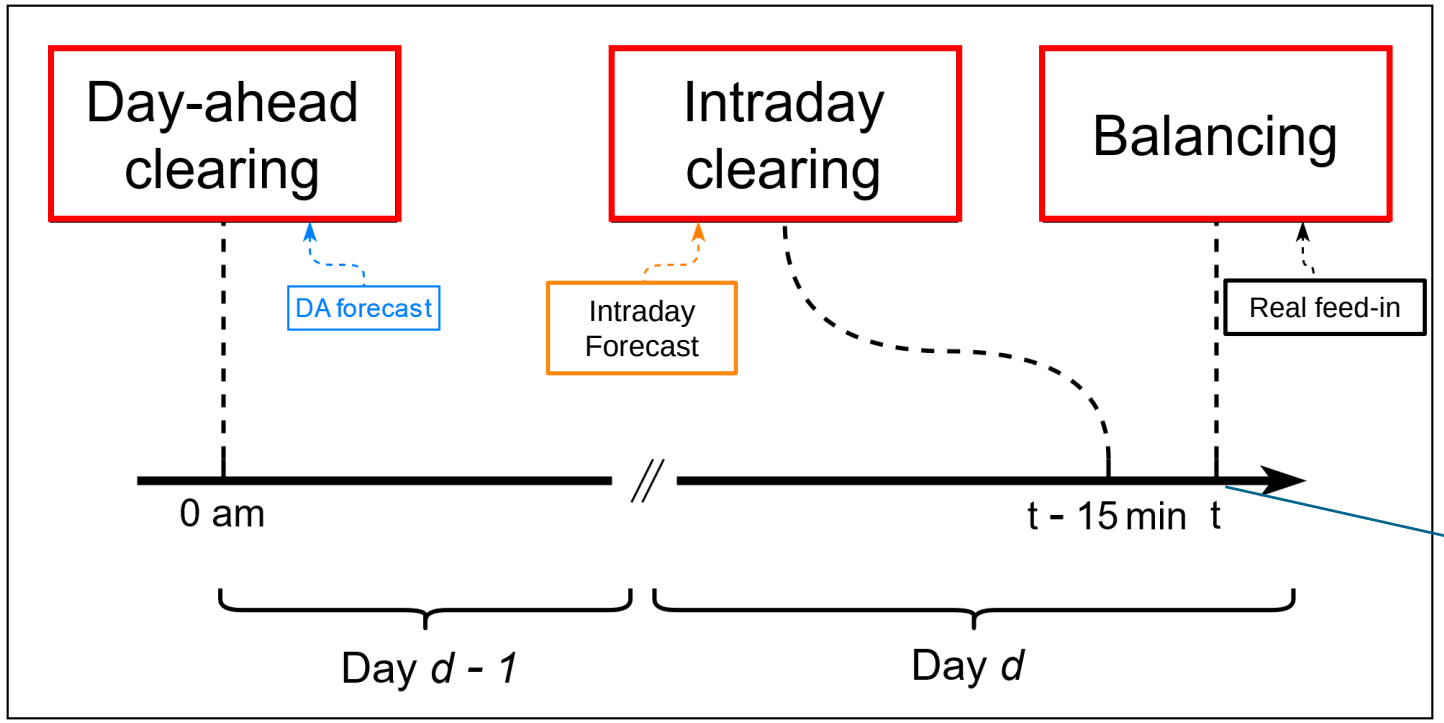
Source: European Centre for Medium-Range Weather Forecasts (ECMWF)

Several issues:

- Decision making in the power system sector bases mainly on deterministic forecasts
- Stakeholders in the power system sector hesitate to change decision processes and
- are reluctant to publish findings

→ **Develop a tool ourselves to simulate the dispatch in a power system utilizing probabilistic feed-in RES forecasts**

ProPower: Tool for power system dispatch modelling utilizing RES feed-in forecasts

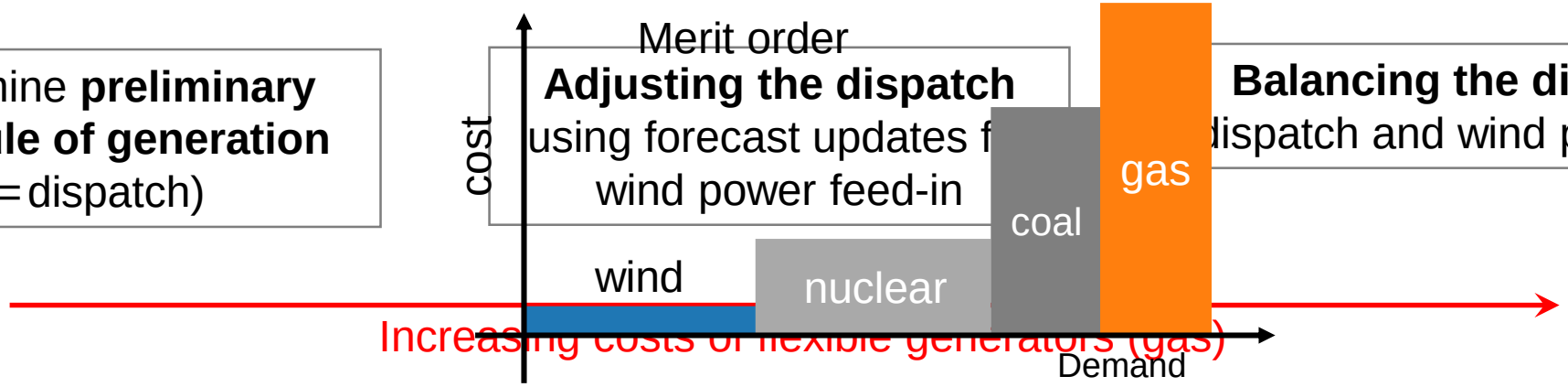


Determine **preliminary schedule of generation** (=dispatch)

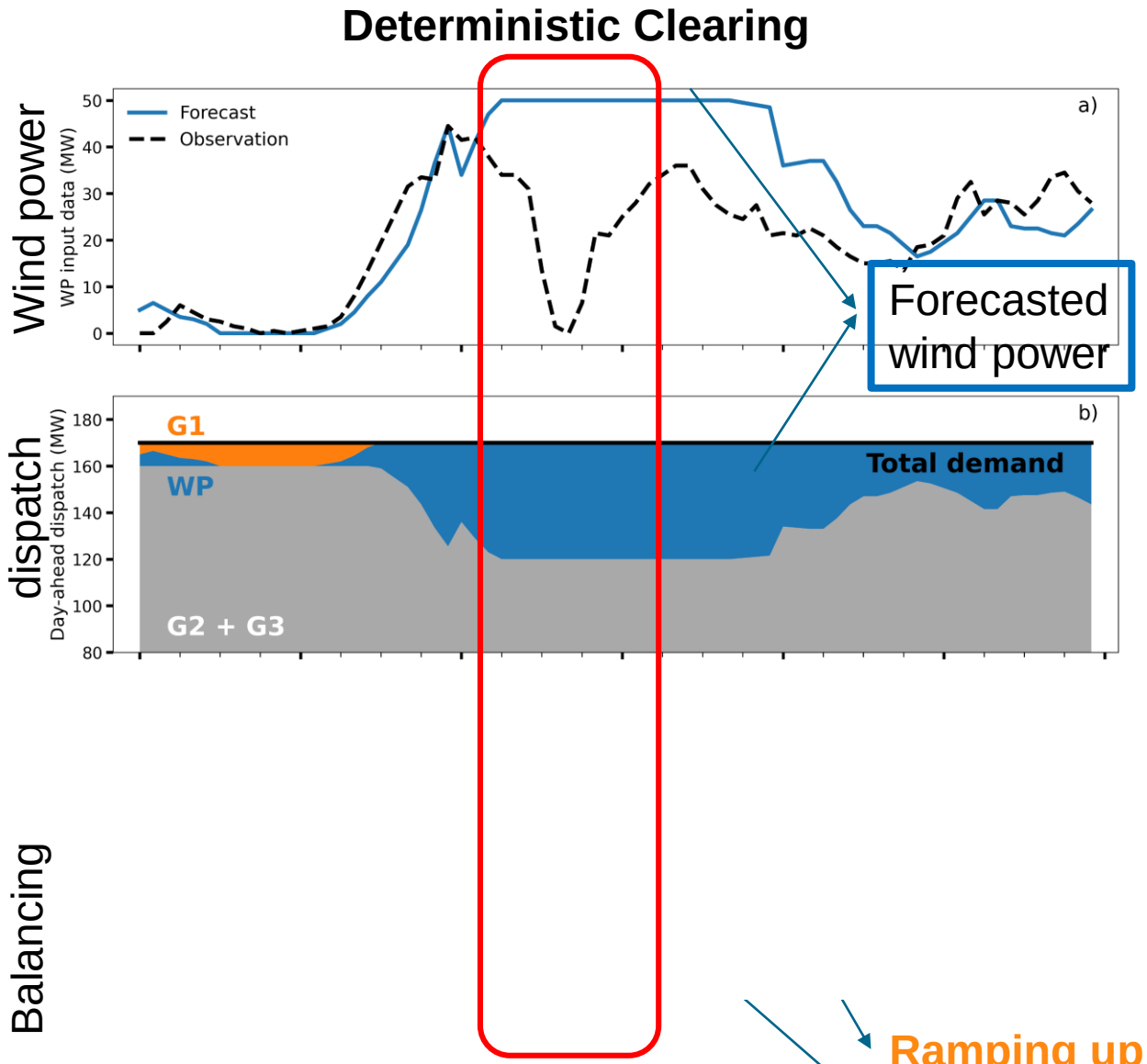
Merit order

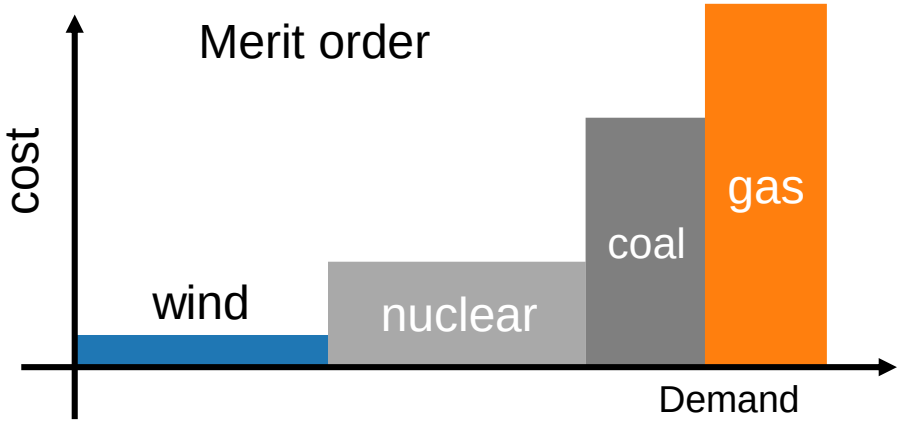
Adjusting the dispatch using forecast updates f wind power feed-in

Balancing the difference of dispatch and wind power feed-in



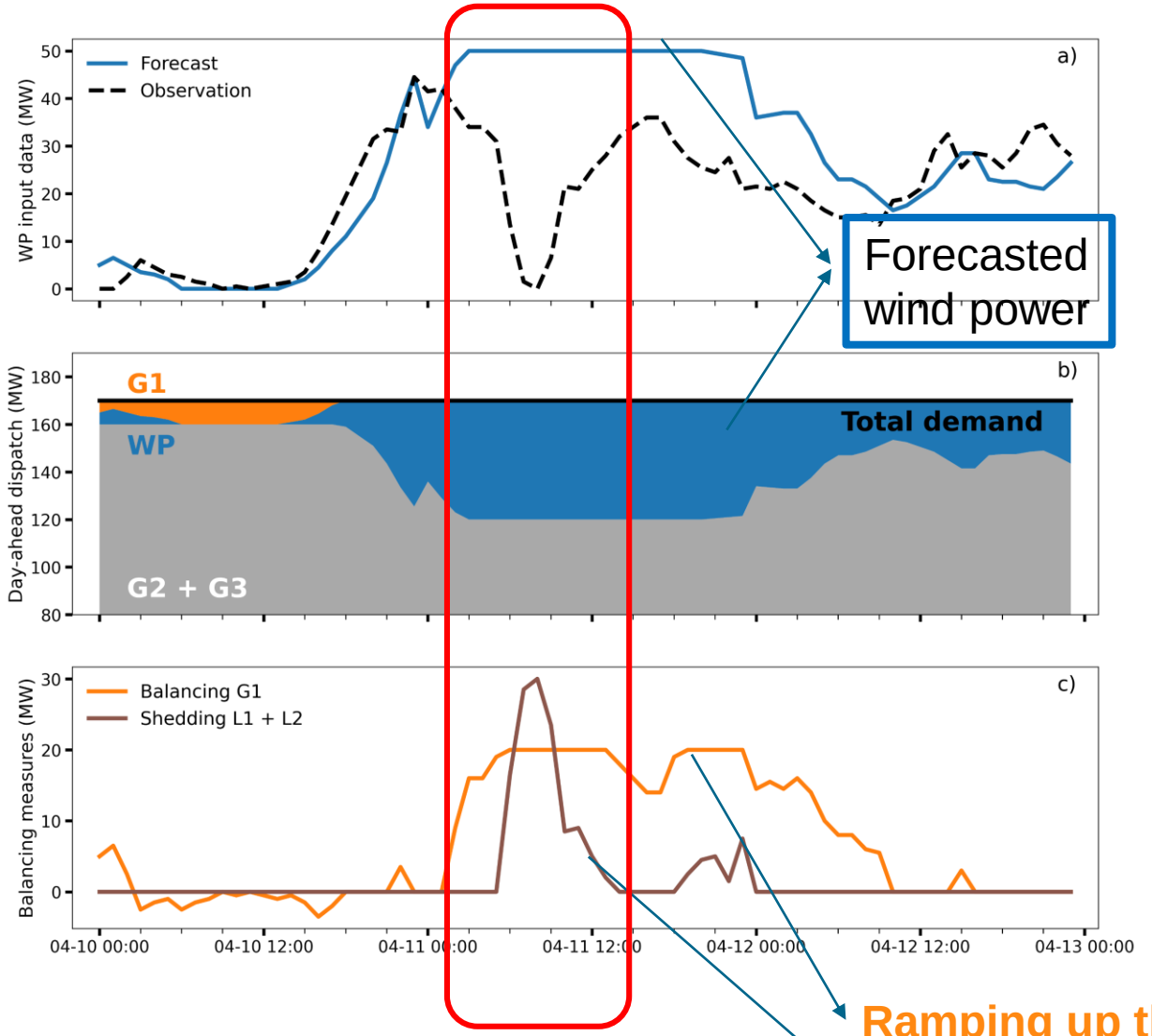
Motivation: How to use probabilistic information?





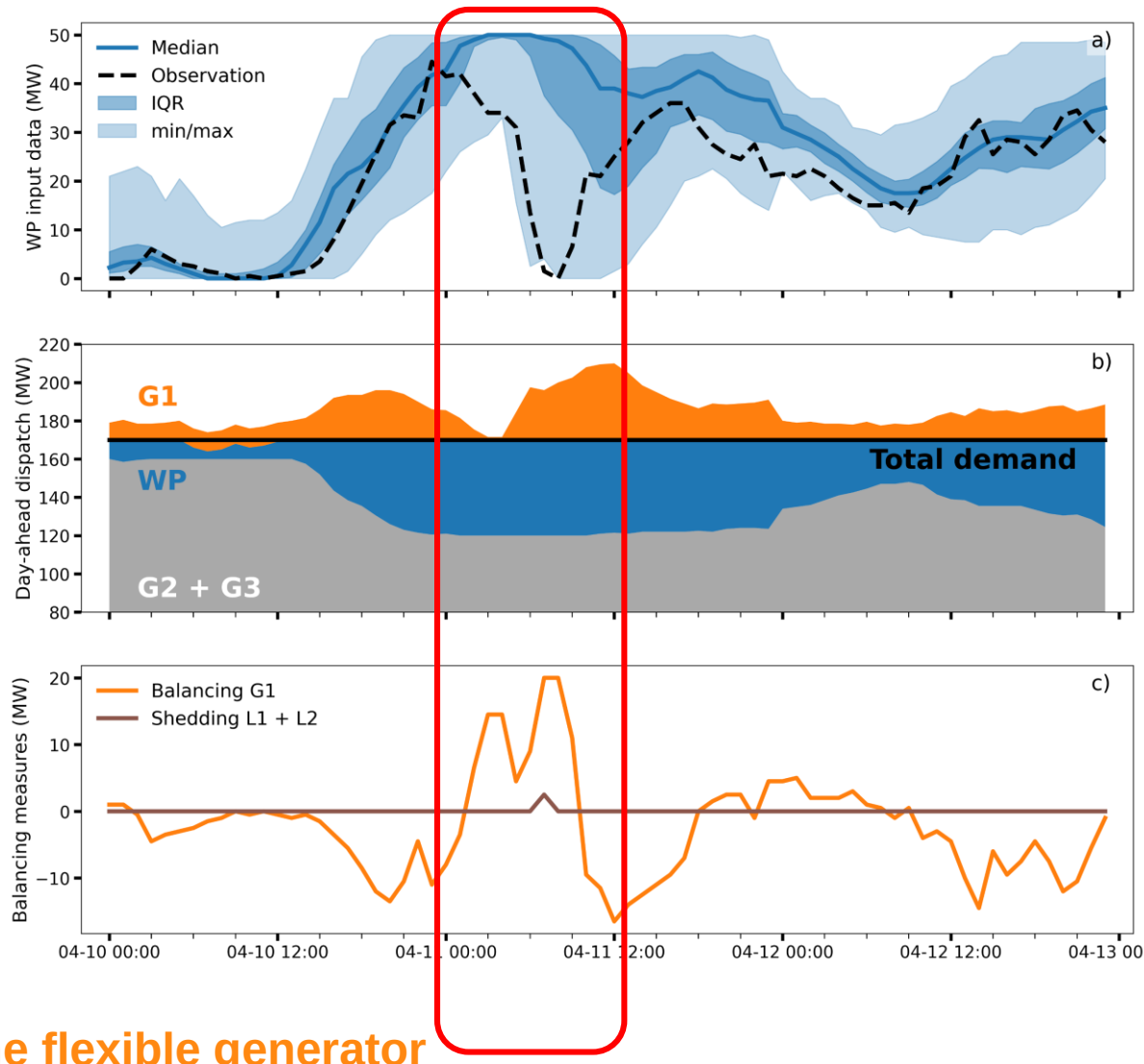
Motivation: How to use probabilistic information?

Deterministic Clearing



Forecasted wind power

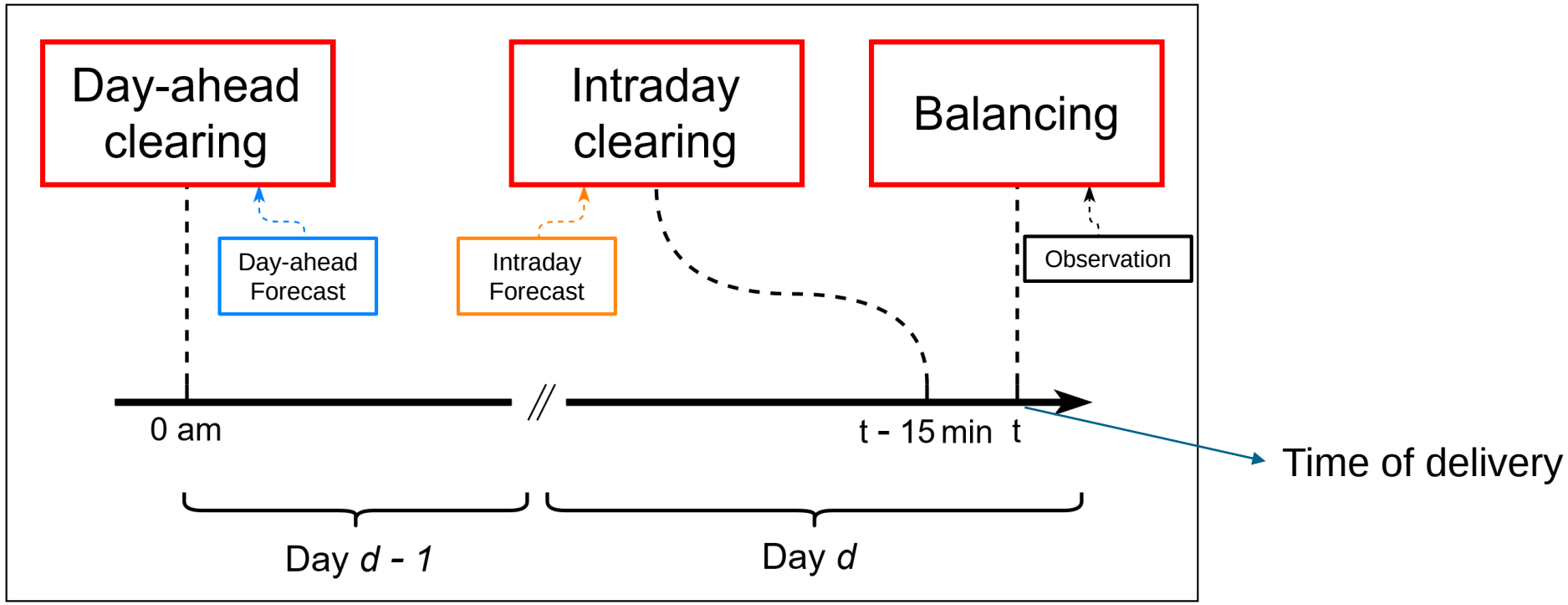
Stochastic Clearing



Ramping up the flexible generator

Shedding of load

ProPower: Tool for power system dispatch modelling utilizing RES feed-in forecasts

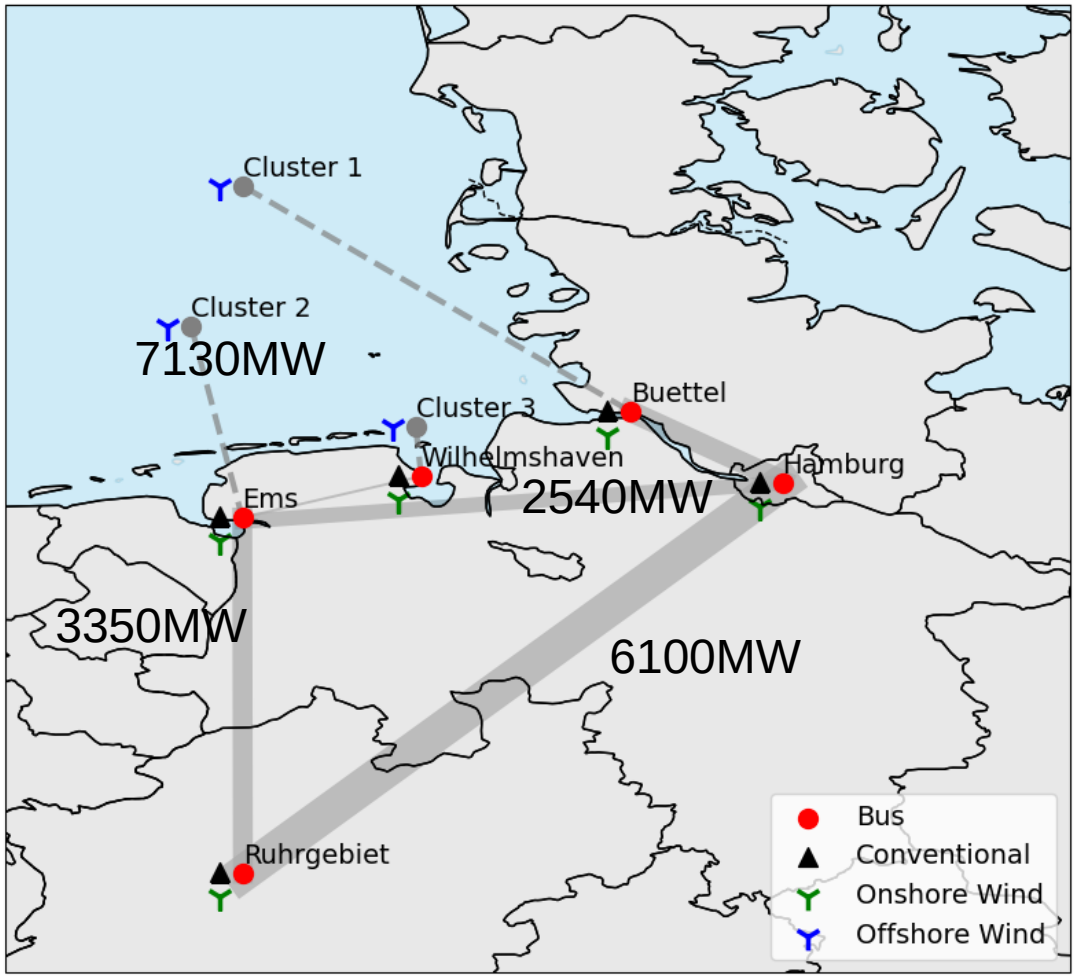


Deterministic	***min***	Day-ahead cost	***min***	Intraday (correction) cost	***min***	balancing costs
Stochastic		+ expected balancing costs		+ expected balancing costs		

Simplyfied network in Northern Germany

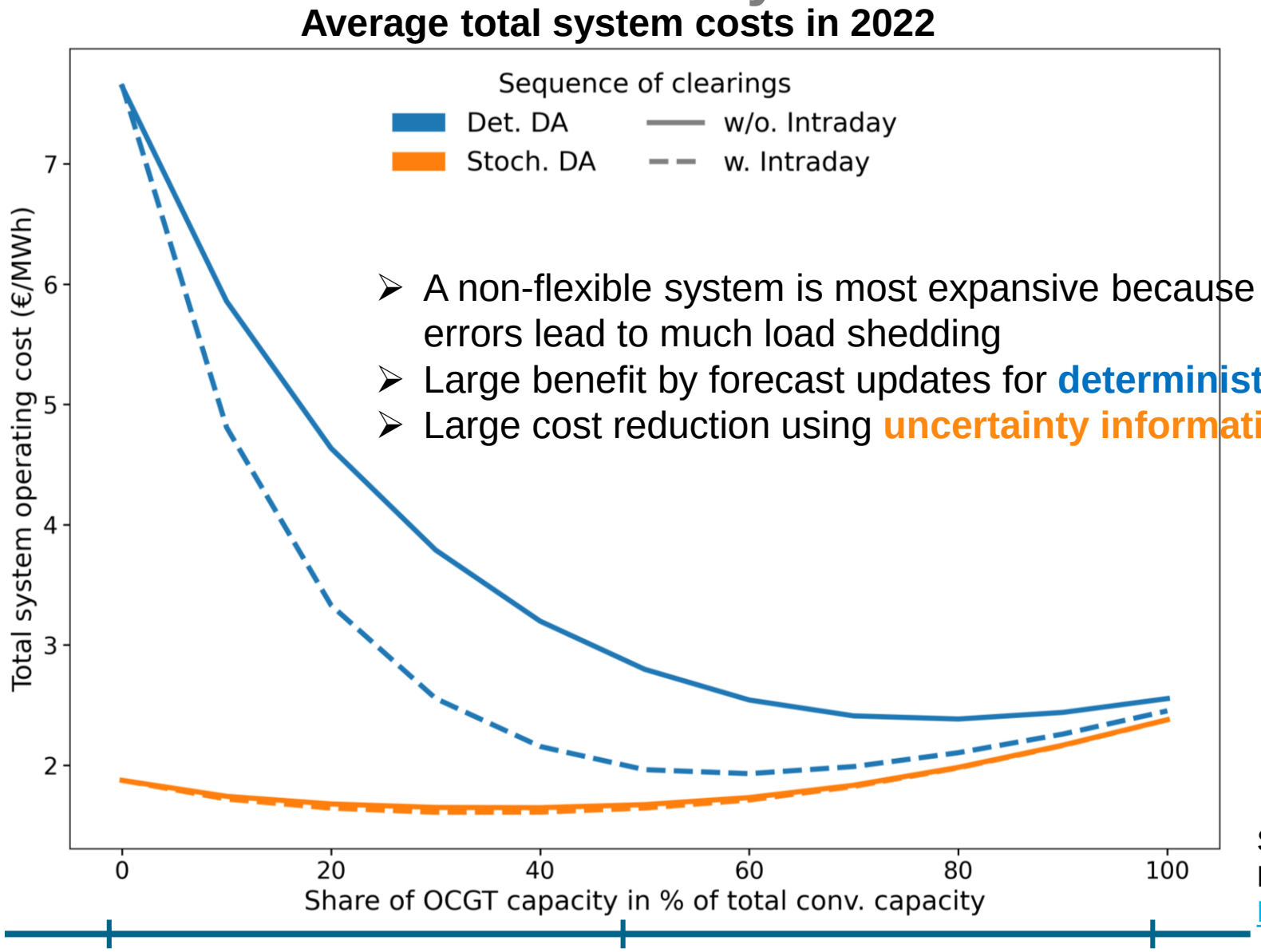
- Layout in *WindRamp* project
- 8,4 GW average load, 21,4 GW peak load
- 25 GW wind farms predicted by ECMWF EPS forecasts (year 2021)
- 22 GW conventional generators with varying shares of flexible generators (gas turbines)
- Flexibility premium up↑: +14%
- Flexibility premium down↓: +3%
- Load shedding: 200 €/MWh

	costs	Ramping flex.
gas	4,5 €/MWh	+20 % / -40 %
„nuclear“	2,6 €/MWh	Not flexible
wind	0 €/MWh	+100% / -100%



Topology of the grid. Load centers: Hamburg und Ruhrgebiet. Wind parks in the North Sea.

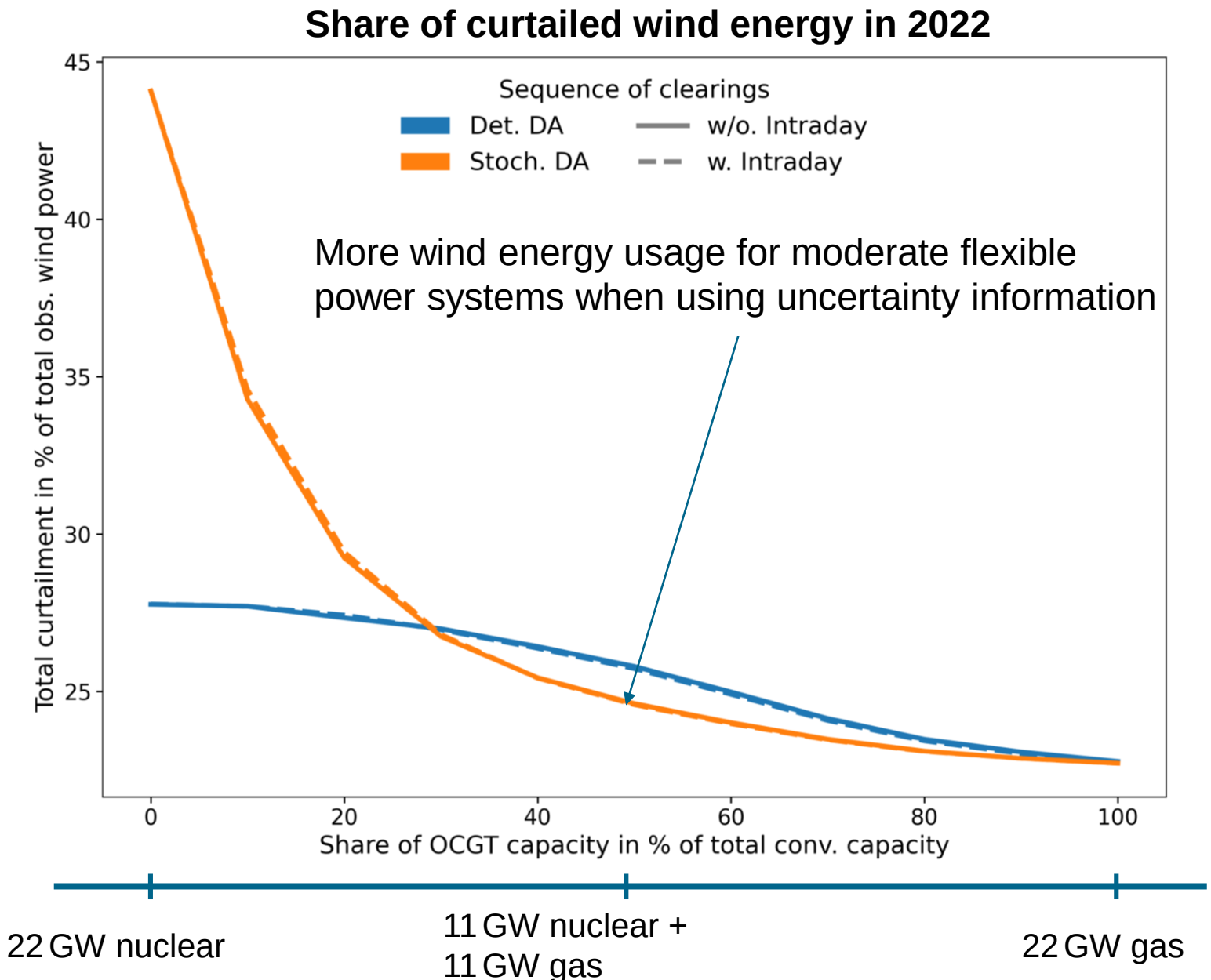
Total System costs with/without intraday



- A non-flexible system is most expansive because pos. fc errors lead to much load shedding
- Large benefit by forecast updates for **deterministic clearing**
- Large cost reduction using **uncertainty information**

Source:
Bents, Hauke
Master Thesis 2023

Curtailed wind energy with/without intraday



Source:
Bents, Hauke
Master Thesis 2023

Simulated use case: Probabilistic Lidar shortest-term forecasts for a 7.13 GW offshore wind park cluster used for intraday clearing

Flexible share for conventional generation (gas): 40%

		Unkalibriert	Kalibriert	Persistenz
$\langle \mathrm{CRPS} \rangle_{n,s,t}$	%	4,67	4,07	4,23
$E^{\mathrm{delivered}}_{\mathrm{Wind}}$	TWh	11,00	11,00	11,00
$E^{+,*}_{\mathrm{OCGT}}$	TWh	0,27	0,31	0,34
$E^{-,*}_{\mathrm{OCGT}}$	TWh	-0,73	-0,63	-0,64
E^{+}_{OCGT}	TWh	0,33	0,28	0,28
E^{-}_{OCGT}	TWh	-0,72	-0,81	-0,83
E^{shed}	TWh	0,03	0,02	0,02
$\mathcal{C}^{\mathrm{total}}$	10^6 €	222,33	217,59	217,80

power purchase at intraday

positive balancing power

- Successful demonstrating the impact of ensemble calibration

Source:
WindRamp Project
Final Report 2024

Summary

- Design of a tool (ProPower) to quantify the value of deterministic and probabilistic wind power feed-in forecasts in a simplyfied power system including market clearing, DC power flows, network constraints, generator costs and load profiles
- Including uncertainty information reduces system costs to a large extent, calibrated forecasts are outperforming
- Intraday forecasts have great value for deterministic clearing, less for stochastic clearing

Outlook

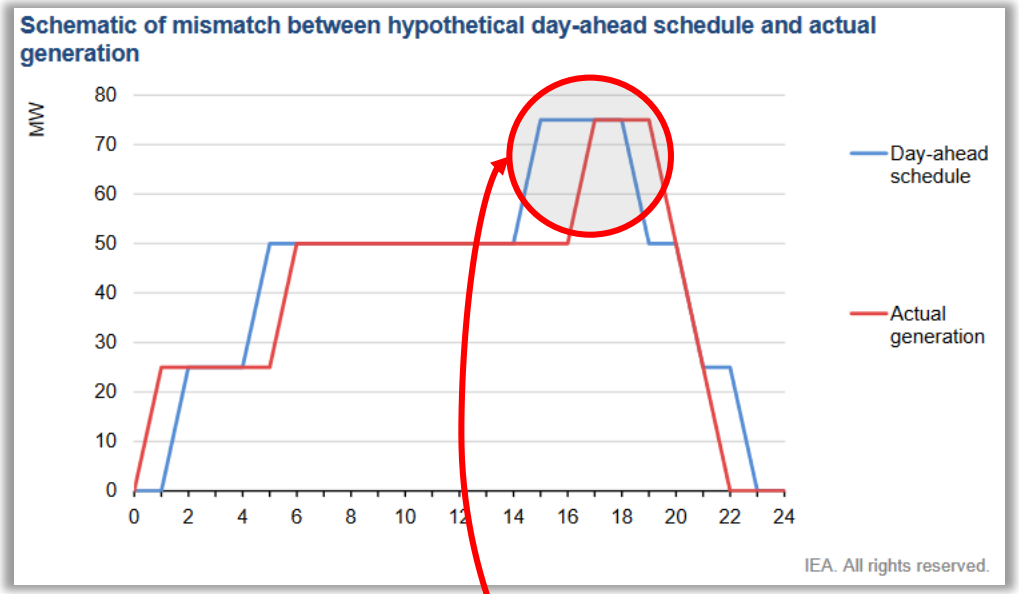
- Extend the power system layout, include PV
- More sensitivity studies on generators costs
- Characterize the interplay between forecast skill and flexibility costs to balance forecast errors utilizing flexible gas turbines, storage, load shifting

Funding received by **WindRamp, FKZ 03EE3027C & WindRamp II, FKZ 03EE3101**

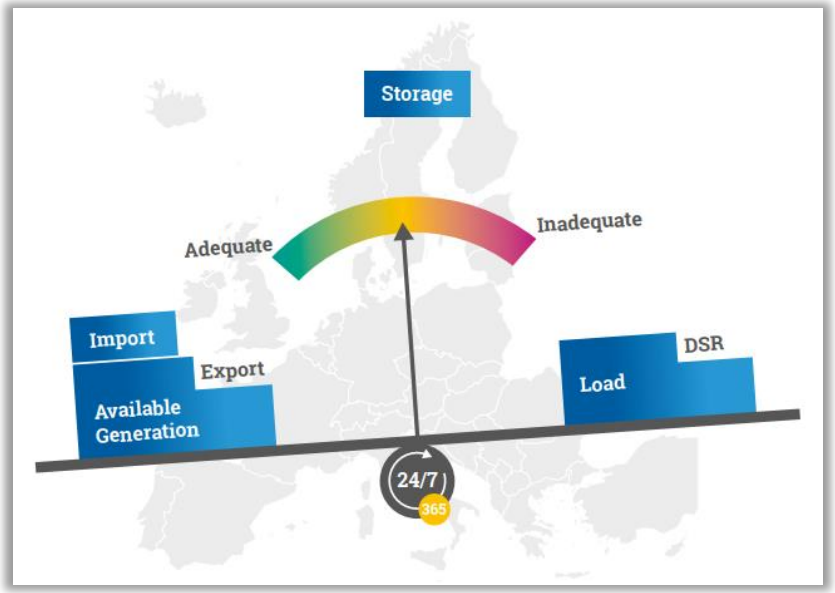
Supported by:
Federal Ministry for Economic Affairs and Climate Action
on the basis of a decision by the German Bundestag

Unsicherheit ist Kernbestandteil im Management des Stromsystems

Planung des Betriebs



Betrieb des Systems

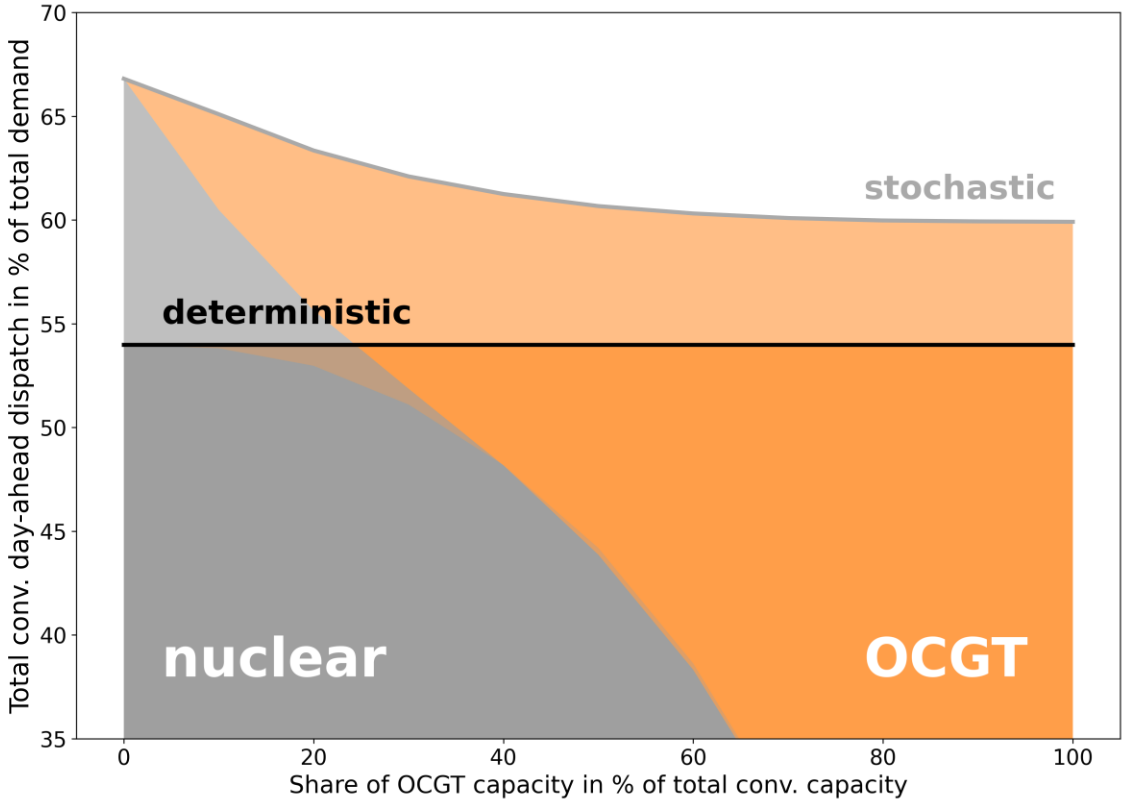


Flexibilität wird zur Korrektur von Fehlern benötigt
→ **Vorhersage von Erneuerbaren immer fehlerbehaftet!**

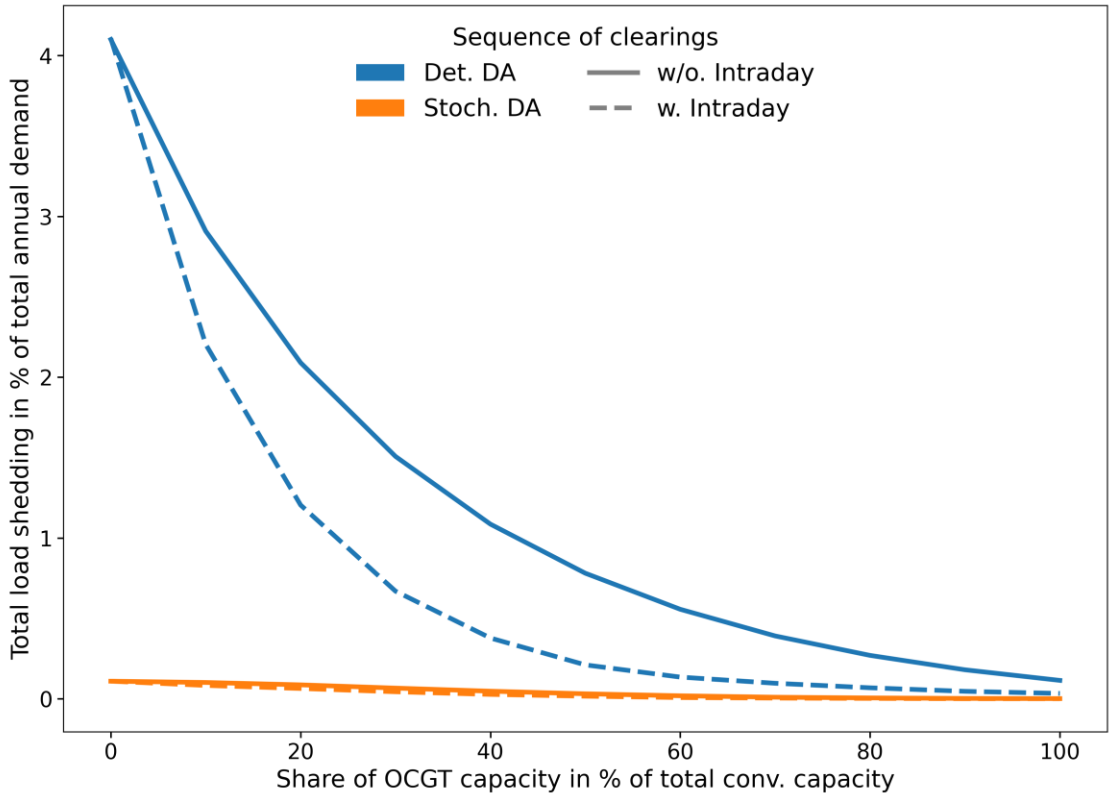
(1) IEA (2020), Electricity security matters more than ever, in *Power Systems in Transition*, Paris: IEA. https://www.iea.org/reports/power-systems-in-transition
(2) ENTSO-E (2023), *European Resource Adequacy Assessment*, Brussels: ENTSO-E. https://www.entsoe.eu/outlooks/eraa/2023/eraa-downloads/

Backup: Vorhersageabhängige Reserve senkt Aktivierung von Flexibilität

Gesamter jhrl. Day-ahead Dispatch



Gesamter jhrl. Lastabwurf



- Stoch. Dispatch senkt Lastabwurf auf < 0.1% unabhängig von OCGT-Installation
- Fehlender flex. Dispatch wird durch Intraday-Clearing abgefedert (*det. Fall*)