

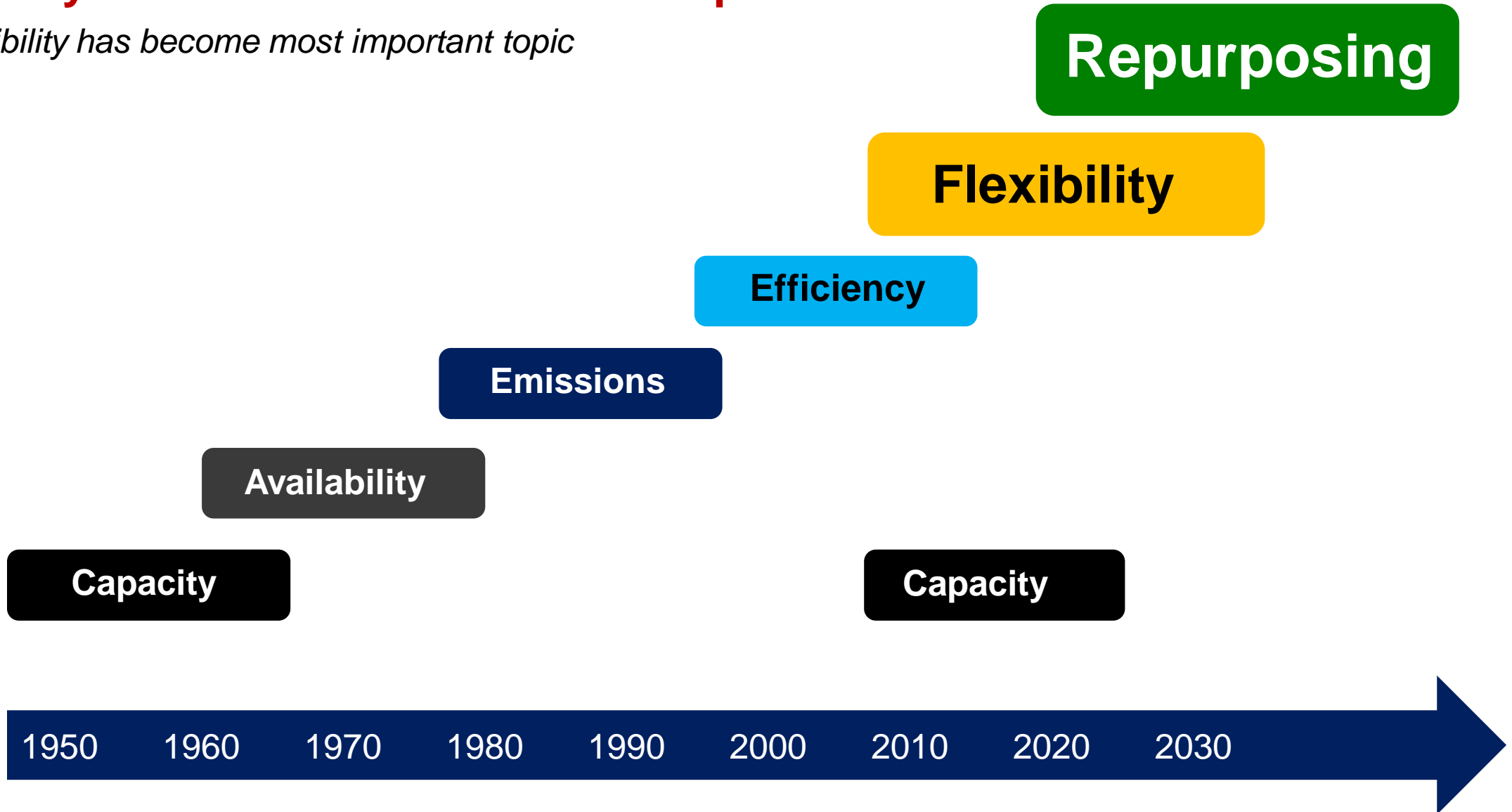


Important role of existing TPS for the energy transition

12th October 2023, Raipur

History of TPS Discussions in Europe

Flexibility has become most important topic



Annual power (energy terms not capacity) from Renewables Germany 2023

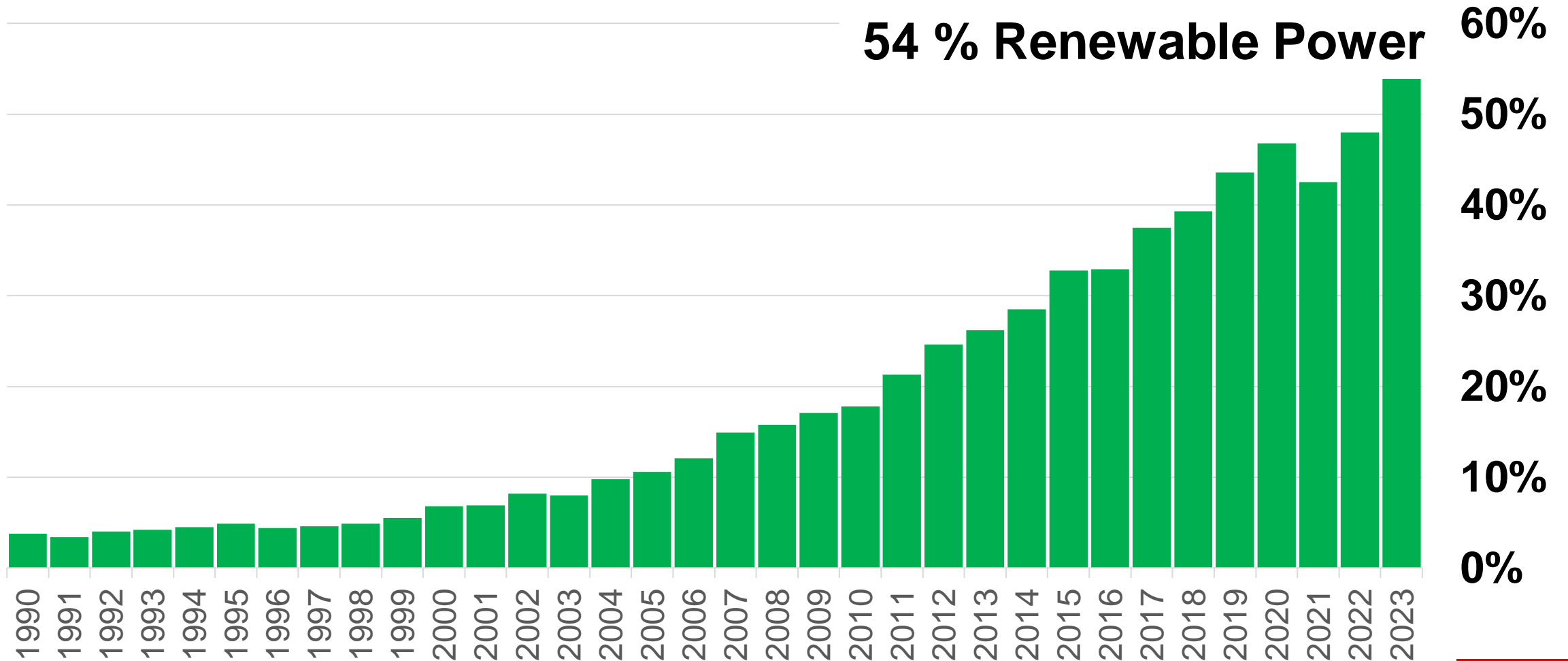
Avg. power from January until 8th of October 2023

54% RE

Annual RE Share in % of Power Demand in Germany

Until 8th Oct. 2023. In 2018 already 2 days with 100% RE share for hours

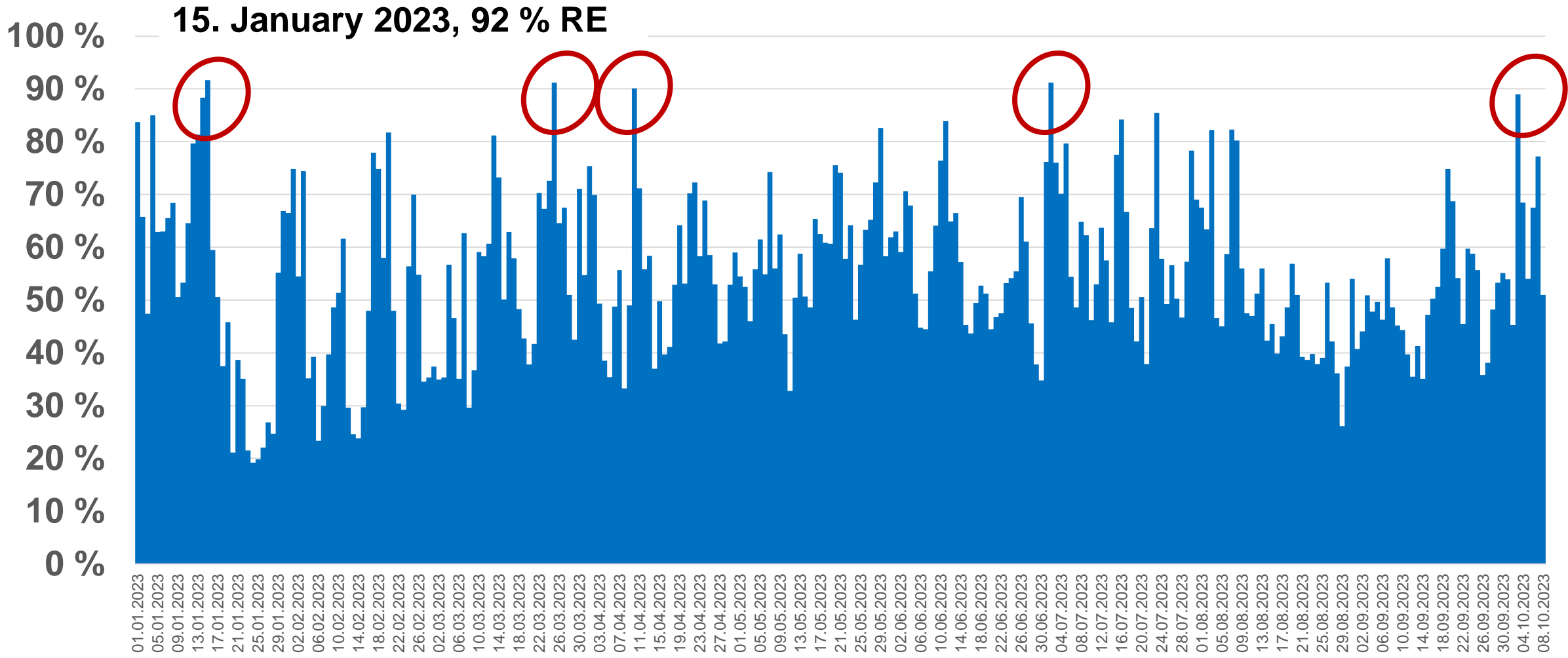
2023
54 % Renewable Power



Source: [Energycharts](#)

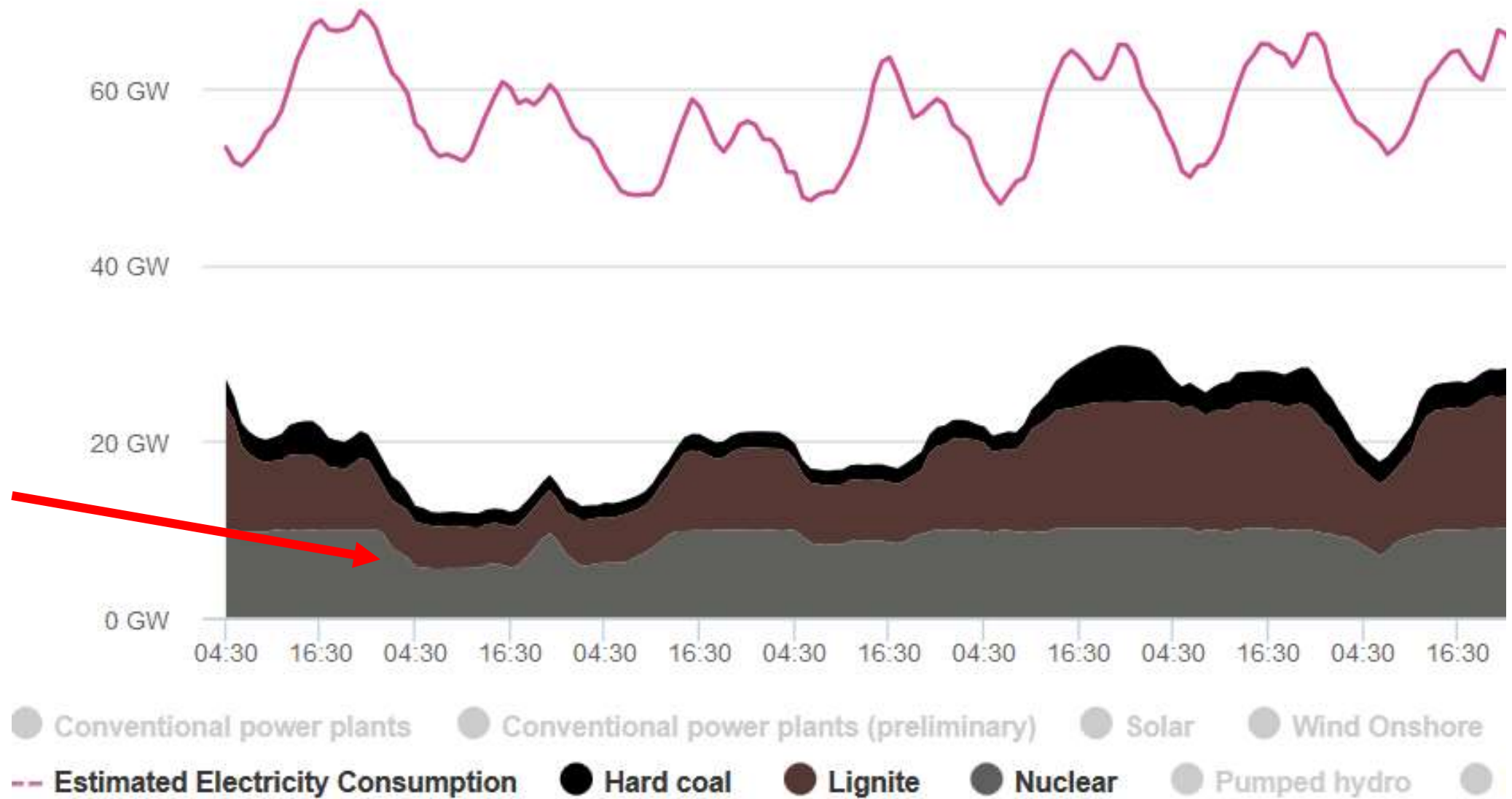
Daily RE Share in % of Power Demand in Germany

On hourly basis there is several days a year since 2018 with +100% RE power supply



Source: [Energycharts](#)

Even NUCLEAR is ramping up and down, a week in December in Germany



Annual avg. powercut duration (in min) per connection in Germany in 2021

13 min.

Source: [Bundesnetzagentur 2023](#)

Annual power (energy terms) from Solar+Wind in Western Region in 2022

% RE?

Annual power (energy terms) from Solar+Wind in Western Region 2022

But some Indian states already comparable to Germany

11% RE

Highest 24 hours power (energy terms) from Solar+Wind in WRegion 2022



Highest 24 hours power (energy terms) from Solar+Wind in WRegion 2022

Some Indian states already comparable to Germany

23% RE

Source: NLDC, Grid-India

Max. instantaneous Solar+Wind penetration (energy terms) WRegion 2022



Max. instantaneous Solar+Wind penetration (energy terms) WRegion 2022

Karnataka already comparable to Germany

35% RE

Source: NLDC, Grid-India

Wind and Solar Penetration Levels in India in 2022

Some states show penetration levels similar to Germany!

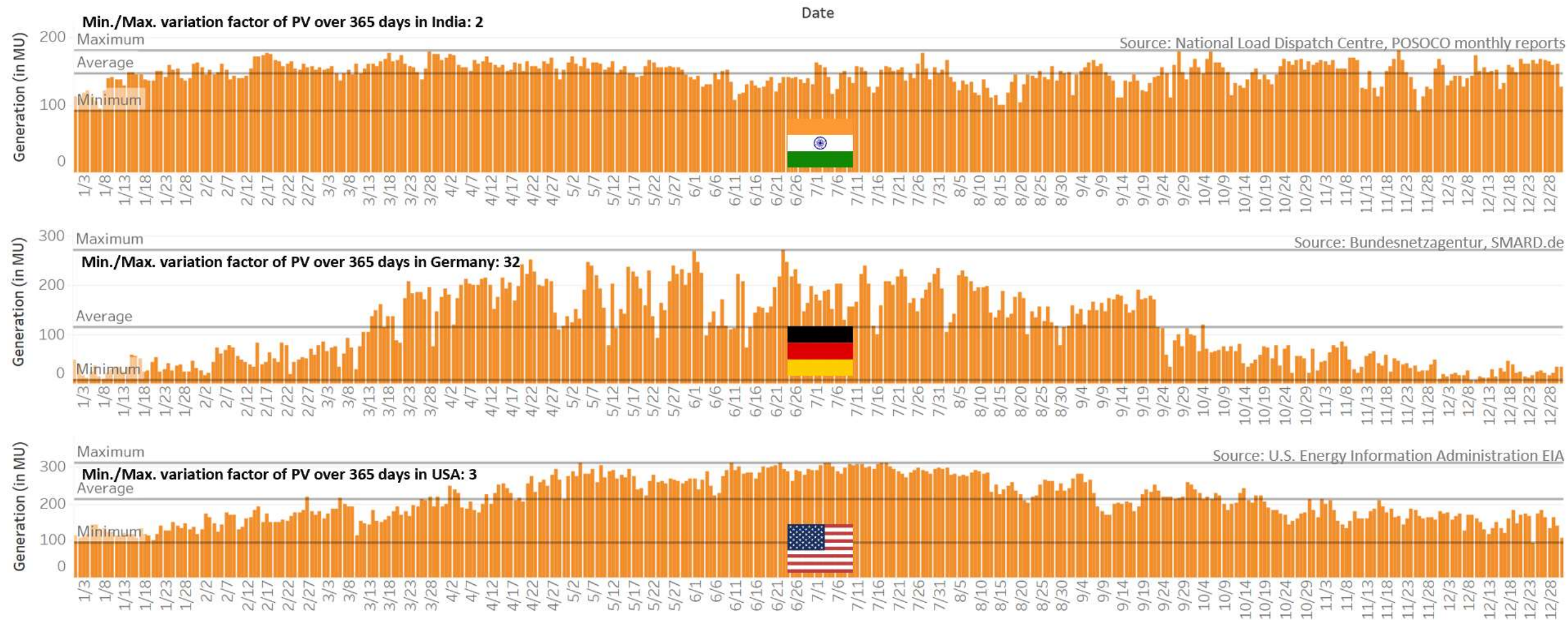
Region/State (FY 2022-23)	Annual Solar+Wind Penetration (Electricity in %)	Max. Daily Solar+Wind Penetration (Electricity in %)	Max. Instantaneous Solar+Wind Penetration (Electricity in %)
Karnataka	27.52	65.38	132.00
Andhra Pradesh	20.50	58.59	81.00
Tamil Nadu	18.42	50.08	77.00
Southern Region	16.91	36.32	61.00
Rajasthan	14.57	35.81	56.00
Gujarat	15.44	35.80	55.80
Madhya Pradesh	11.01	32.40	53.90
Telangana	12.17	17.63	49.00
Northern Region	10.56	18.36	46.75
Maharashtra	10.10	23.00	37.21
Western Region	11.03	23.10	35.13
All India	11.01	20.40	31.80

Source: NLDC, Grid-India

...in some states some days already exceed 50 % RE power

India has high solar energy security

365 days of PV generation in India, Germany and USA in 2020

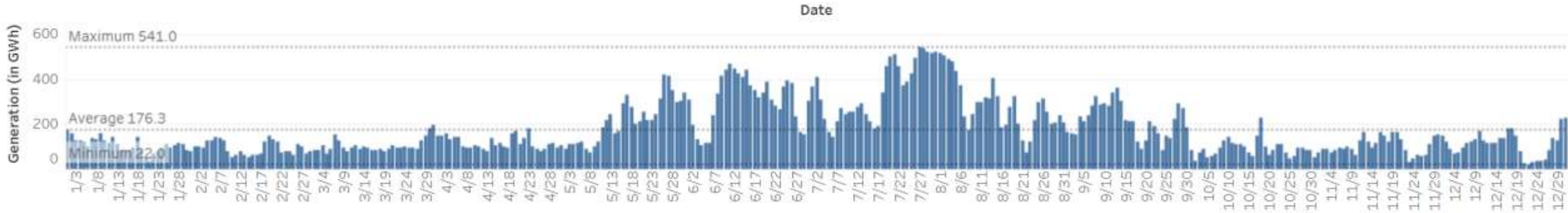


Good wind conditions

365 days of generation from wind in India and Germany (year 2021)

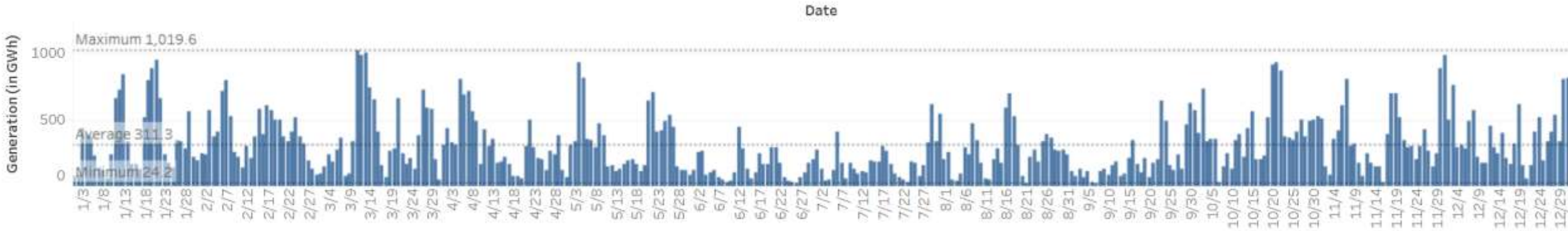


India



Source: National Load Despatch Centre, POSOCO monthly reports

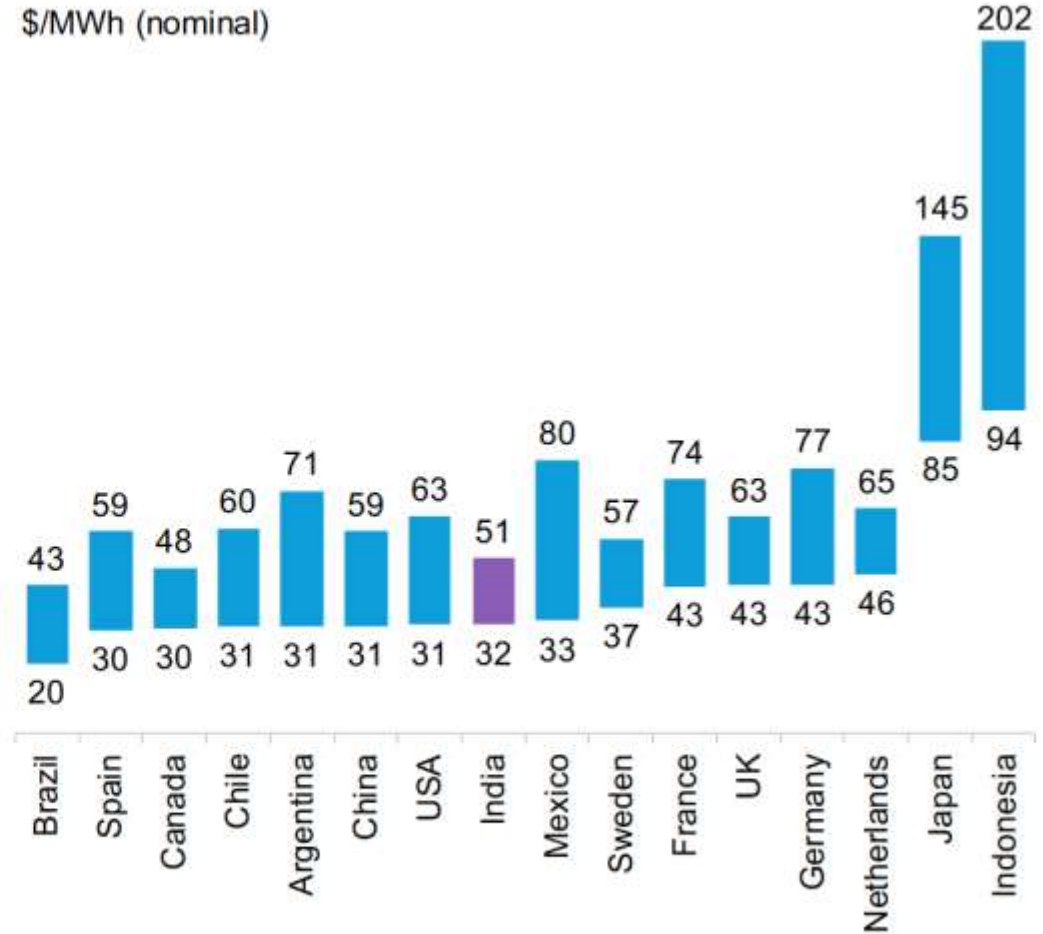
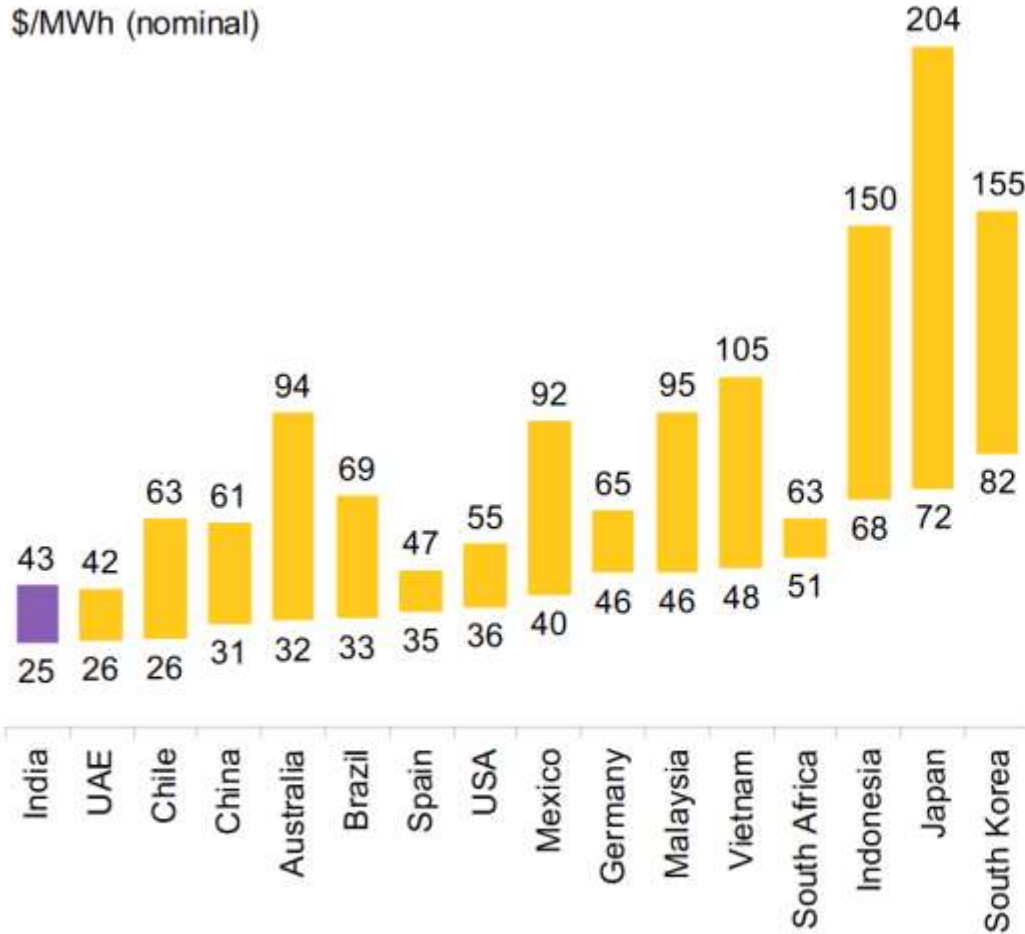
Germany



Source: Bundesnetzagentur, SMARD.de

India generates wind and solar power cheaper than many others

LCOE for fixed-axis PV and onshore wind in India, 2021



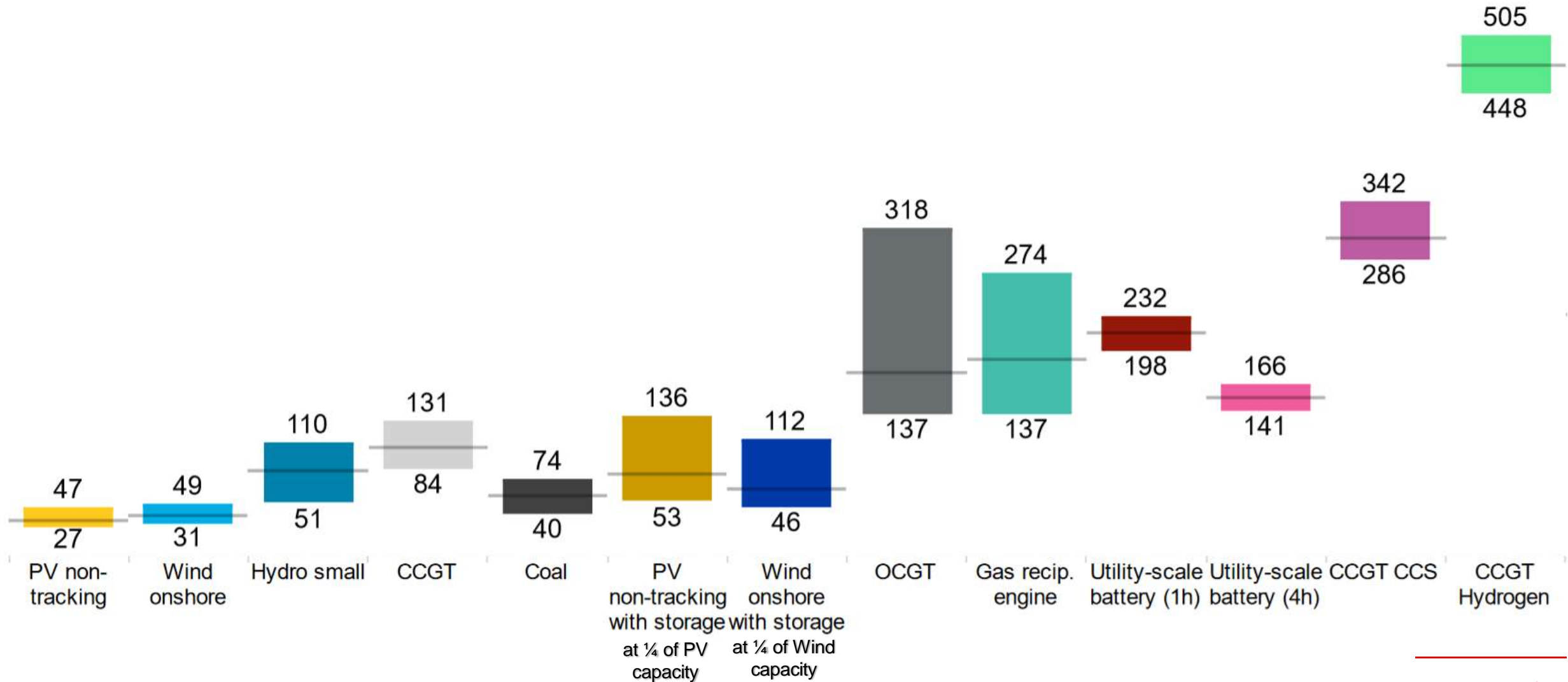
Source: BloombergNEF. Note: The range of the LCOE represents a range of costs and capacity factors. All LCOE calculations are unsubsidized and exclude curtailments and tax-credits.

Source: BloombergNEF. Note: The range of the LCOE represents a range of costs and capacity factors. All LCOE calculations are unsubsidized and exclude curtailments and tax-credits.

**What is the largest
energy storage
available in India?**

LCOE range (USD/MWh, nominal) in India, 1st Half 2022

Current LCOE of coal is based on calculations with PLF above 50 %. Coal is the largest energy storage.



Flexibility is Value

...as e.g. practiced with RRAS and FRAS.

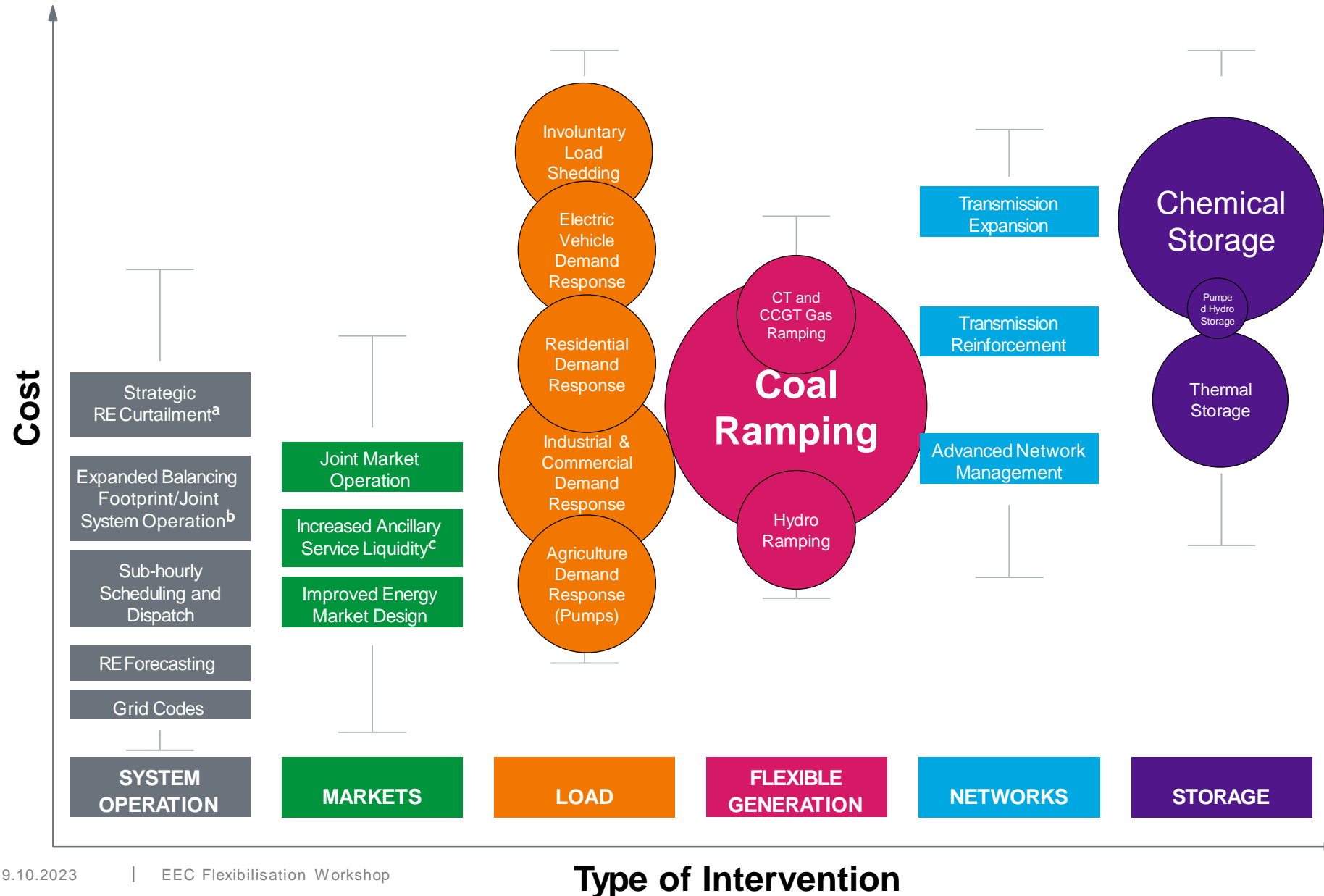
- 1. Value Flexibility and give it a Premium**
- 2. Incentivise Demand Shift + Exports**
- 3. Flexibilise Thermal Units**
- 4. Establish Pumped Storage**
- 5. Establish Battery Storage**

Thank you!
DhanyavaadagaLu!

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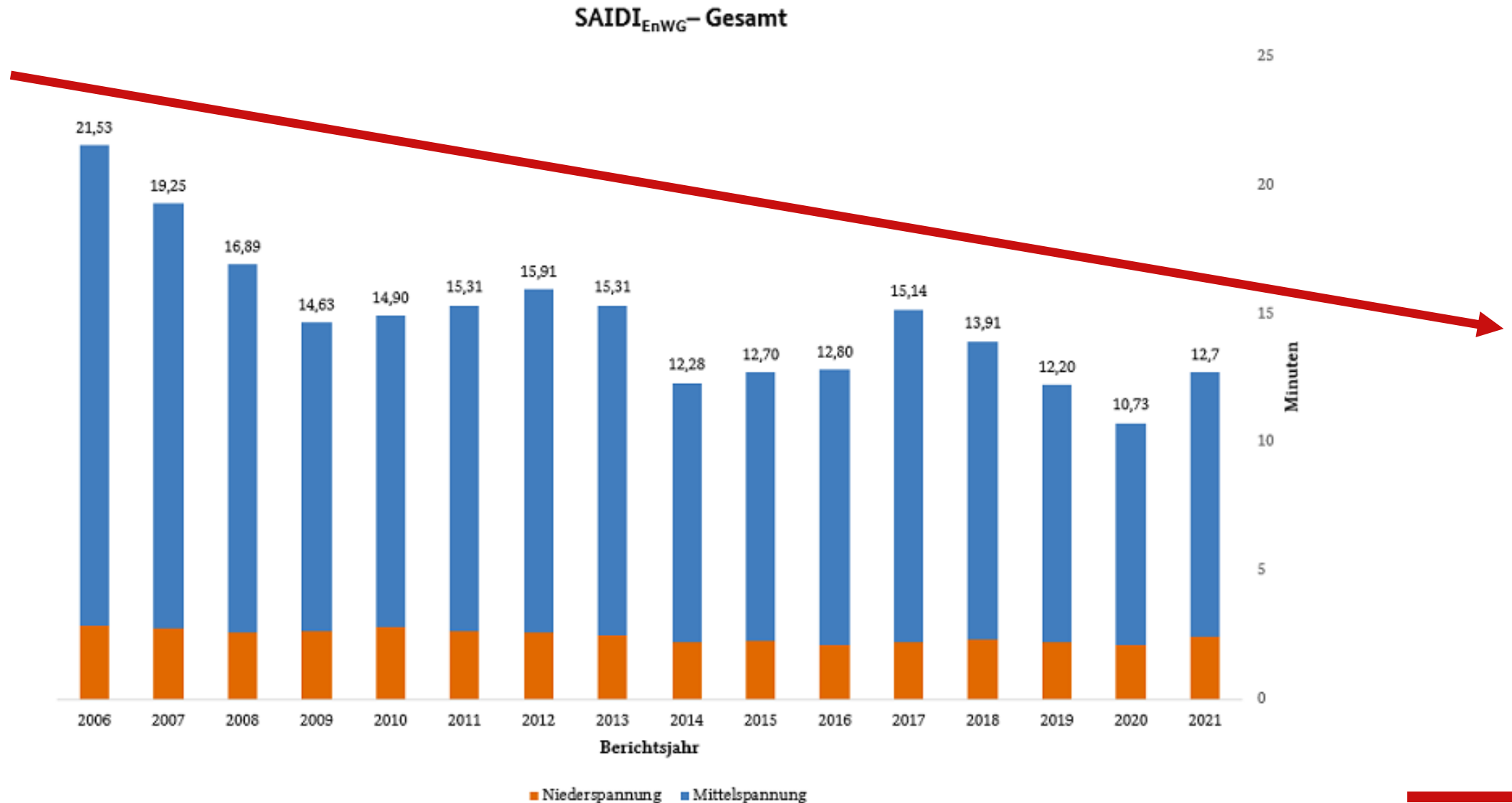
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Coal is largest RE-Integration Option available at reasonable price



Source: <https://www.nrel.gov/docs/fy14osti/61721.pdf>, 2014, S.K. Soonee and others

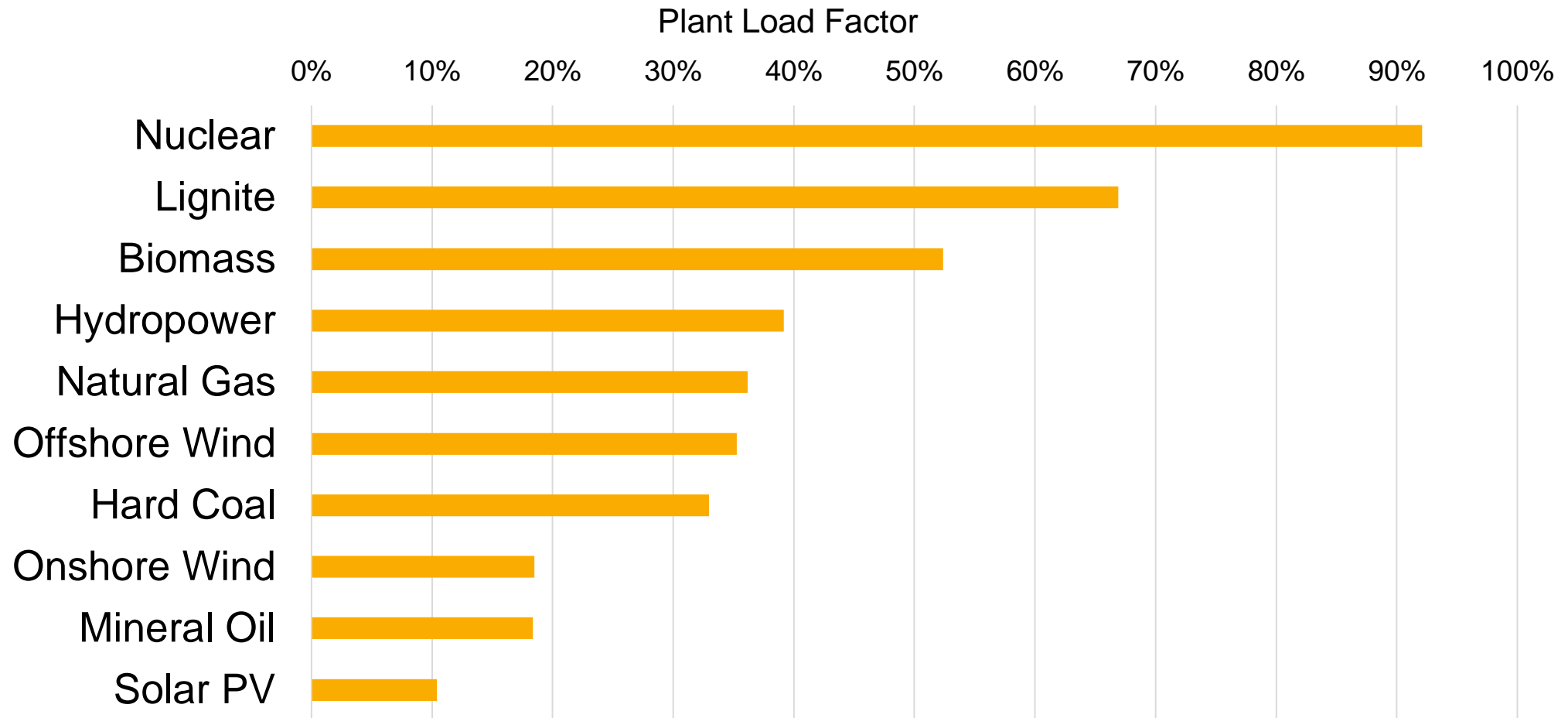
Annual avg. powercut duration (in min) per connection in Germany in 2021



Source: [Bundesnetzagentur 2023](#)

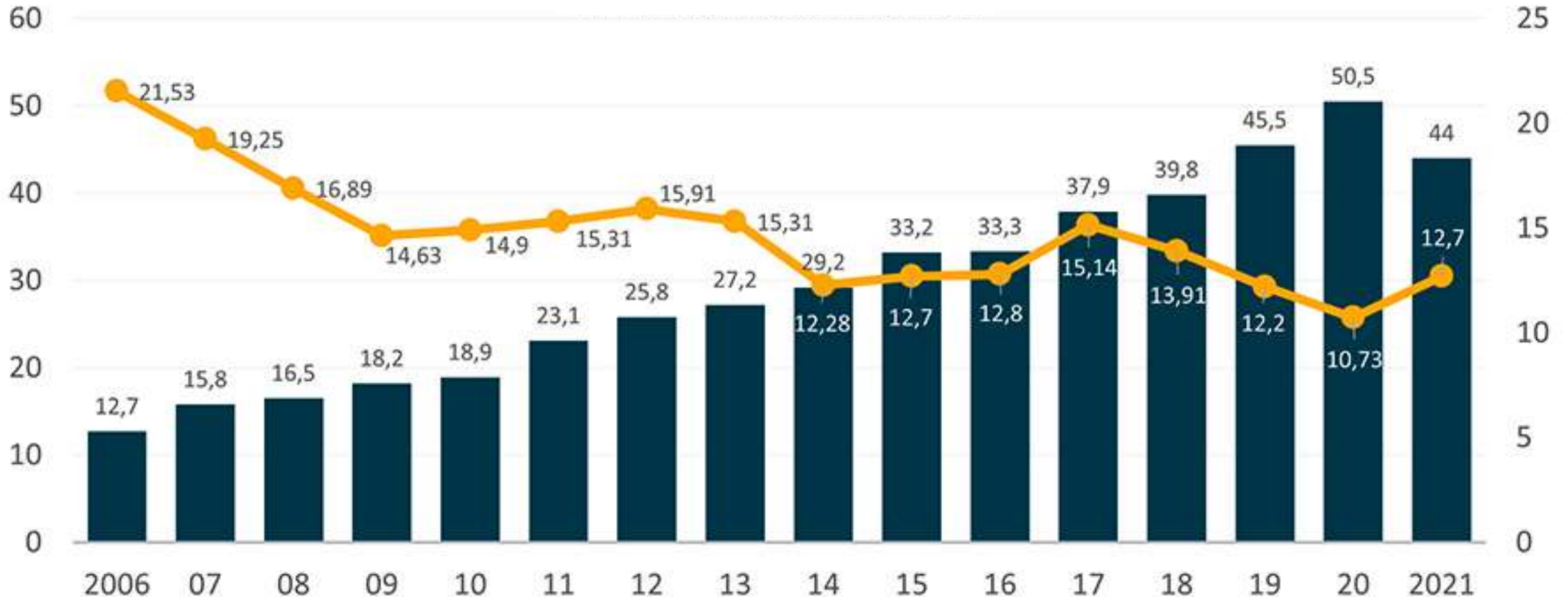
Plant Load Factors for Generation Plants in the Market

In Germany, 2021



Source: BDEW, own graph

Power Outages and Share of Renewables in Energy Generation in Germany



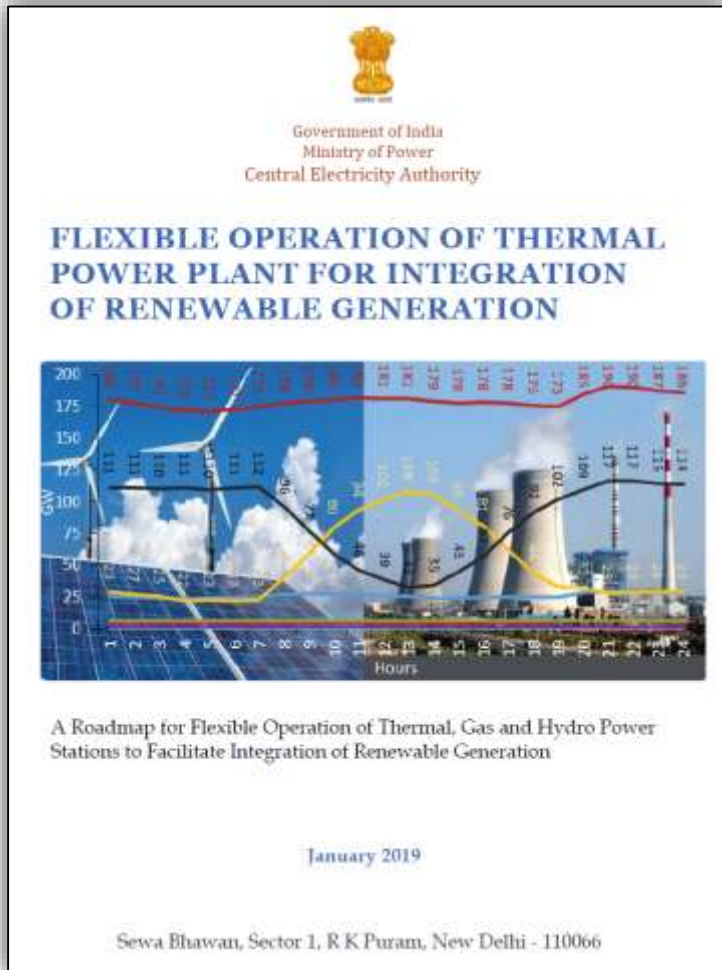
■ Share of Renewables in Energy Generation in %

● Power Outages in Minutes

Source: IKZ.de, Bundesverband Erneuerbare Energie e.V., Bundesnetzagentur

Key message: 175 GW RE require min. 80 GW Flexibility in the System

...to avoid curtailment of RE



By committee (CEA, POSOCO, NTPC) under Ministry of Power, 2019
Lead author: B.C. Mallick, Chief Engineer (TPRM), CEA

- 108 GW peak generation from 175 GW RE assumed in July
- **Daily RE load swings of up to 86 GW**
- Balancing ramp rates of ~300 MW/min. at 9 am and 4 pm

If also considering other generation running in flexible mode as support:

- hydro (+/- 10 GW in July), gas (+/- 5 GW) & pump + battery (+/- 13 GW)
- with old and small size thermal units in two shift operation (+/- 5 GW)
- with up to 1% annual RE curtailment

➔ **at least 50 GW coal ramping required**

➔ **with all coal down to ~57% minimum thermal load (MTL)**

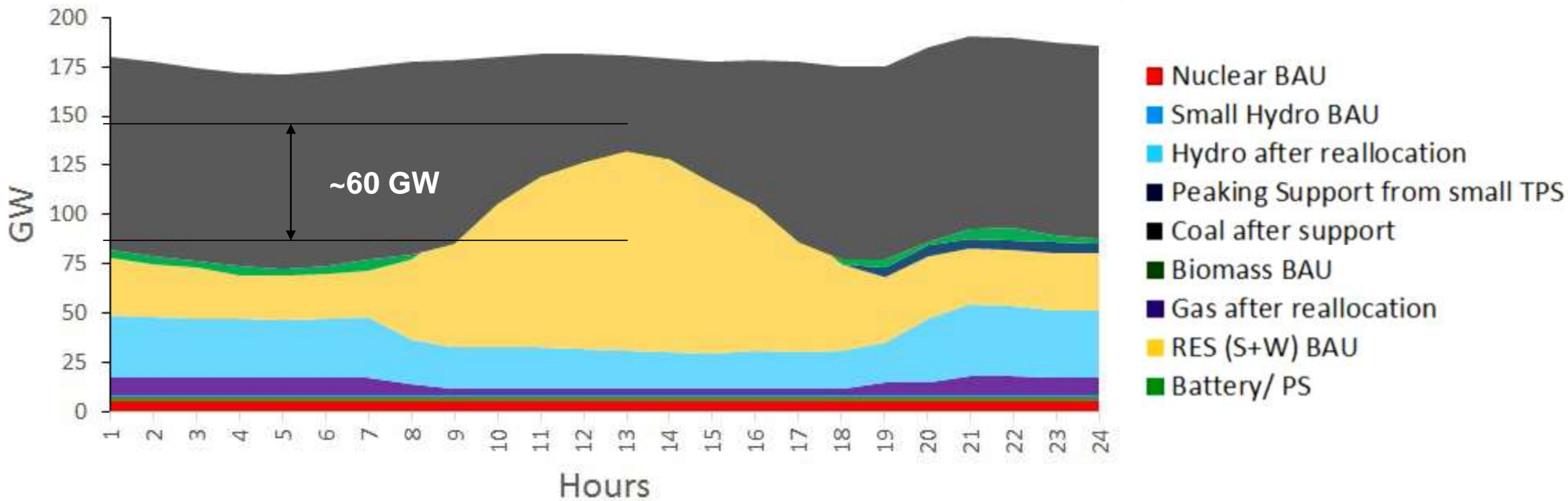
➔ **without flexible support of hydro etc. MTL ~45% for coal**

➔ **without 1% curtailment MTL of ~38% for coal estimated**

➔ **without flexible support and without curtailment MTL ~26%**

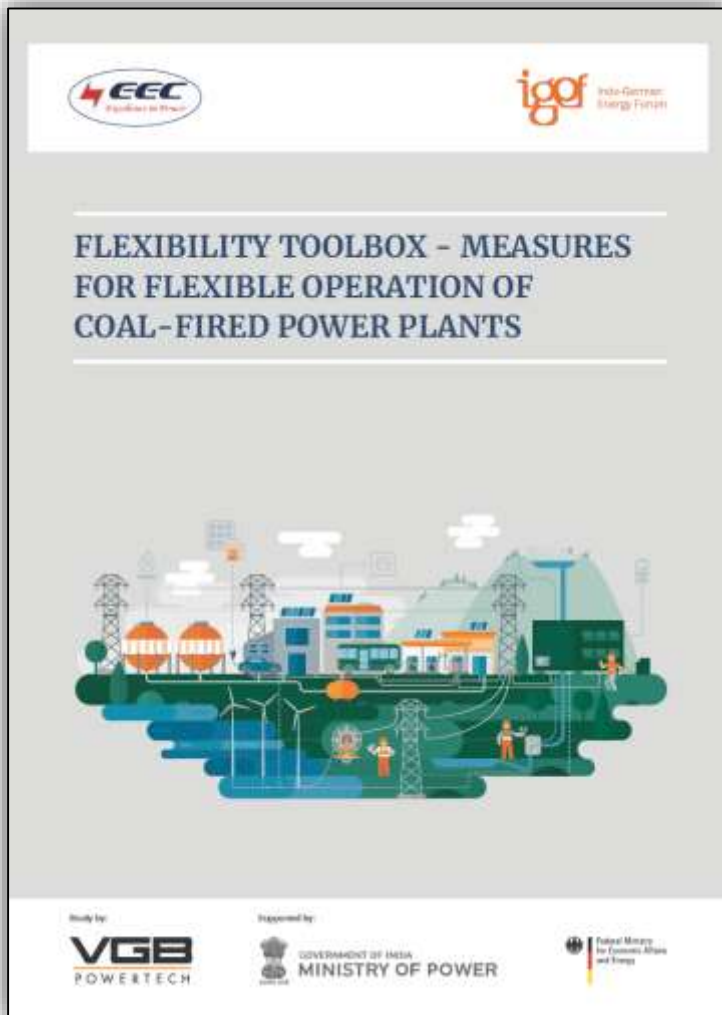
Key message: 175 GW RE require min. 50 GW Coal Ramping

A day in July w/o curtailment requires around 60 GW of Coal Ramping and Flexibility Support from Hydro + Pumped Hydro + Battery + Gas + Small TPS. COVID Light Switch-Off Event was 31 GW total & 1,25 GW/min.



Key message: Low minimum load most important flexibility dimension

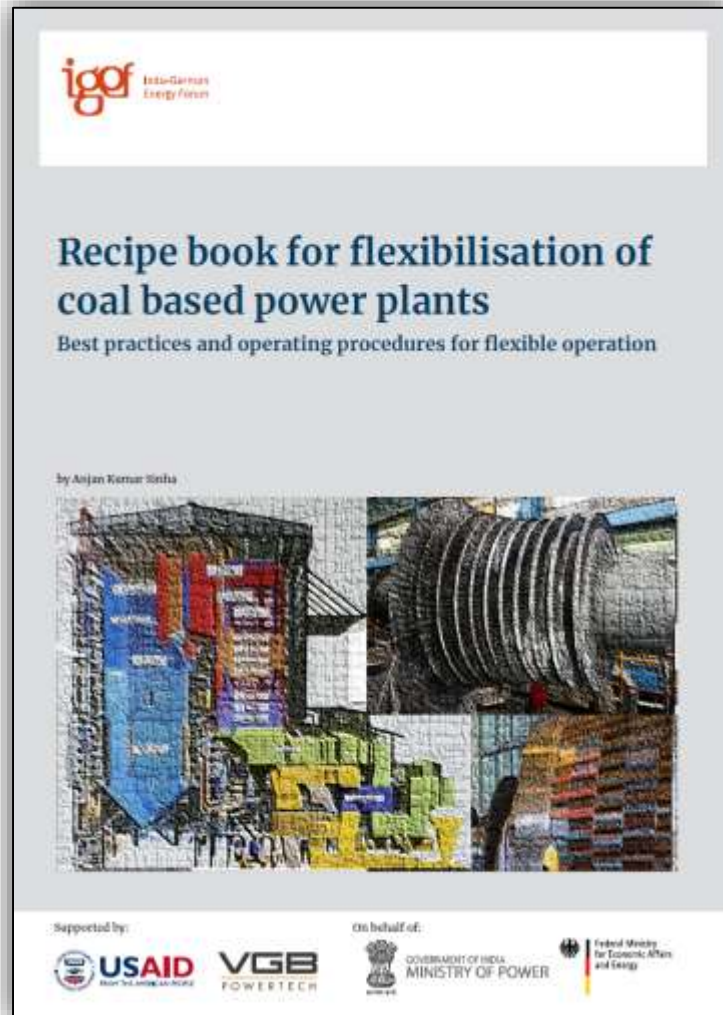
10 steps to achieve flexibility, start with low cost retrofit measures which have highest effect



On behalf of MoP by Task Force Flexibility (NTPC, BHEL, POSOCO, IGEF+VGB+EEC) Lead author: Dr. Claudia Weise, VGB PowerTech e.V.

Plant type in Europe	Hard Coal	Lignite	CCGT
	Conservative / state of the art / very advanced		
Ramp rate [% / min]	2 / 4 / 9	2 / 4 / 8	4 / 8 / 12
in the load range [%]	40 to 90	50 to 90	40* to 90
Minimum load [%]	40 / 25 / 10	60 / 40 / 20	50 / 40 / 30*
Start-up time hot start <8 h [h]	3 / 2 / 1	6 / 4 / 2	1.5 / 1 / 0.5
Start-up time cold start >48 h [h]	7 / 4 / 2	8 / 6 / 3	3 / 2 / 1

36% stable minimum load of coal achieved in India – national record!



On behalf of MoP by Task Force Flexibility (NTPC, BHEL, POSOCO, IGEF+VGB+EEC) Lead author: Mr. Anjan Kumar Sinha, Retd. NTPC

Findings from pilot studies and test runs conducted at various coal-based units in India over the last five (5) years.

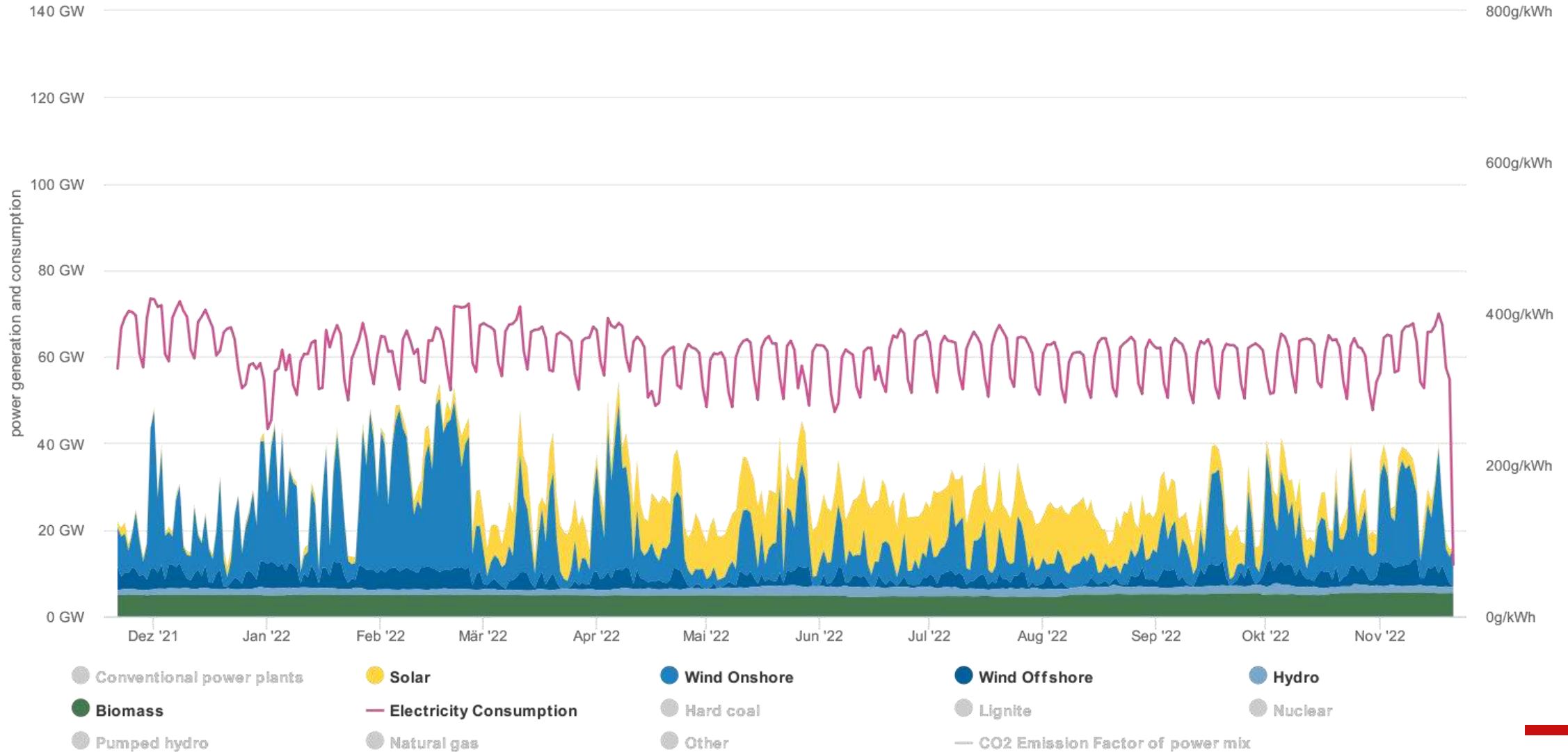
Test runs conducted in India by IGEF Task Force Flexibility on request of Shri Dewanganji. **40% stable minimum load achieved and can be sustained with minimum retrofits** like improved C&I systems, boiler condition monitoring, combustion optimizer, coal analysers etc.

List of **potential damages** which may occur to the power plant if the **power plant operator is not properly trained** in minimum load running and ramping of coal fired plants.

Update: **New national record at JV DVC+TATA Maithon of 36% Minimum Load** achieved by Task Force Flexibility.

Renewable Energy Generation and Total Electricity Consumption

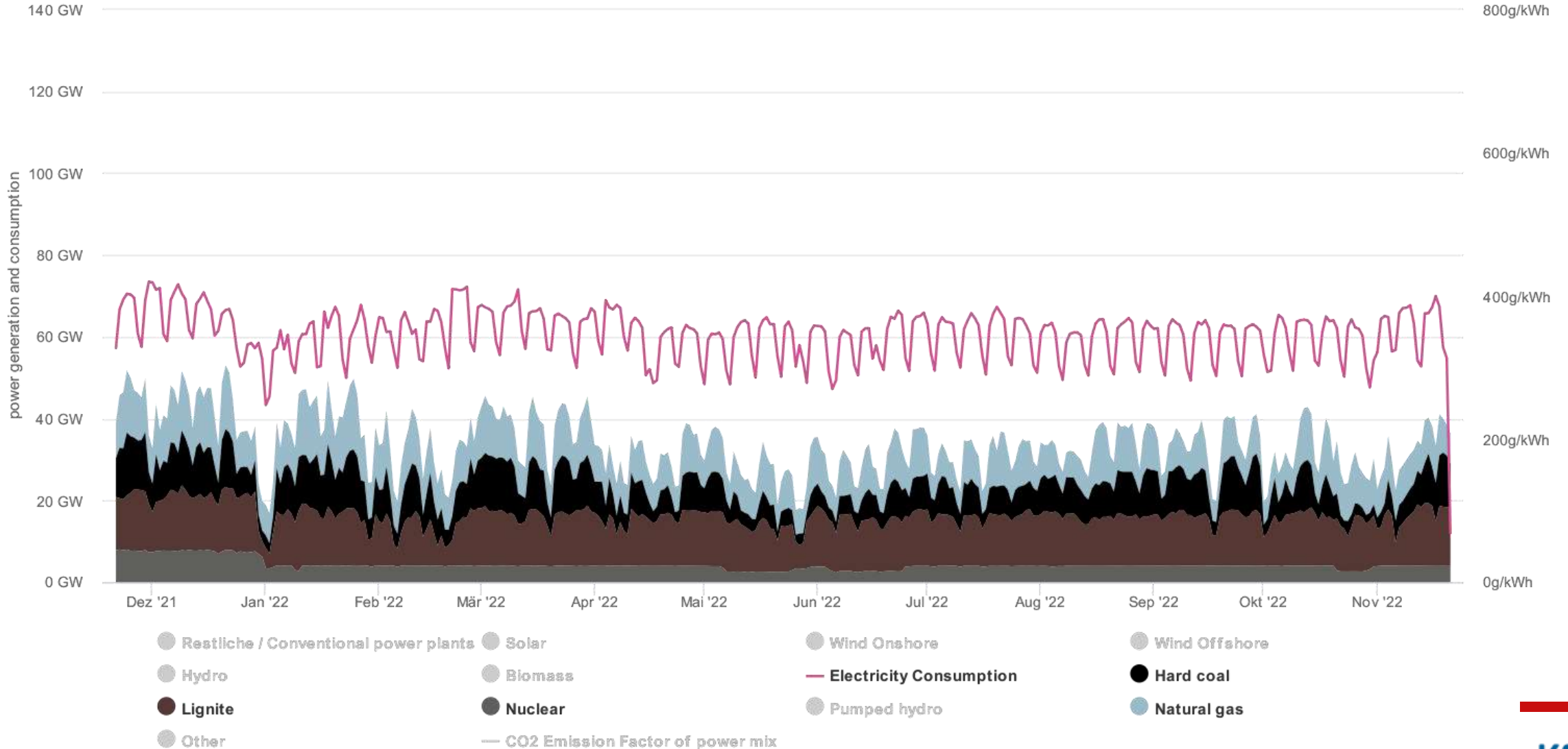
In Germany 21/11/2021-21/11/2022



Source: Agora Energiewende, 21.11.2022

Power Generation from Conventional Sources

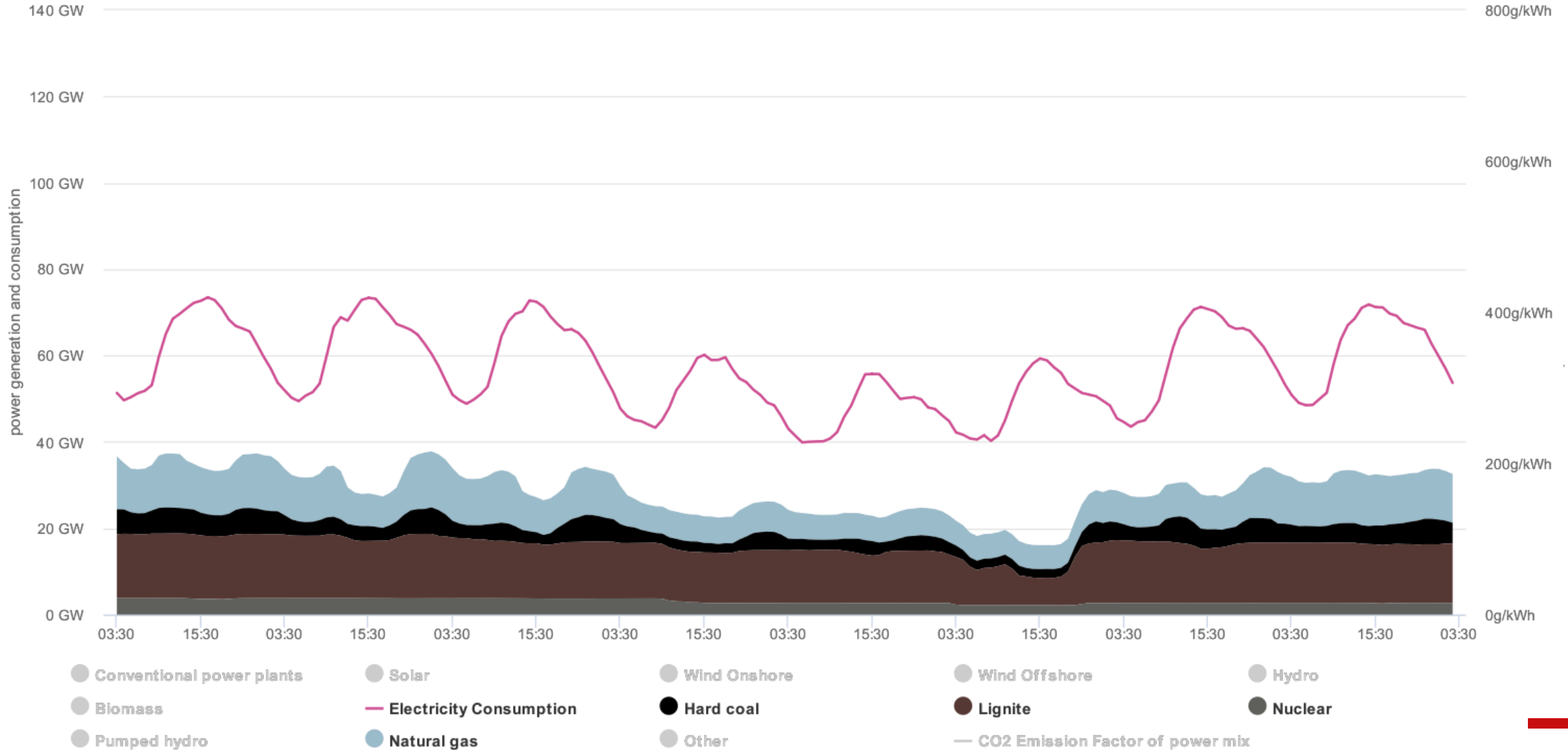
In Germany 21/11/2021-21/11/2022



Source: Agora Energiewende, 21.11.2022

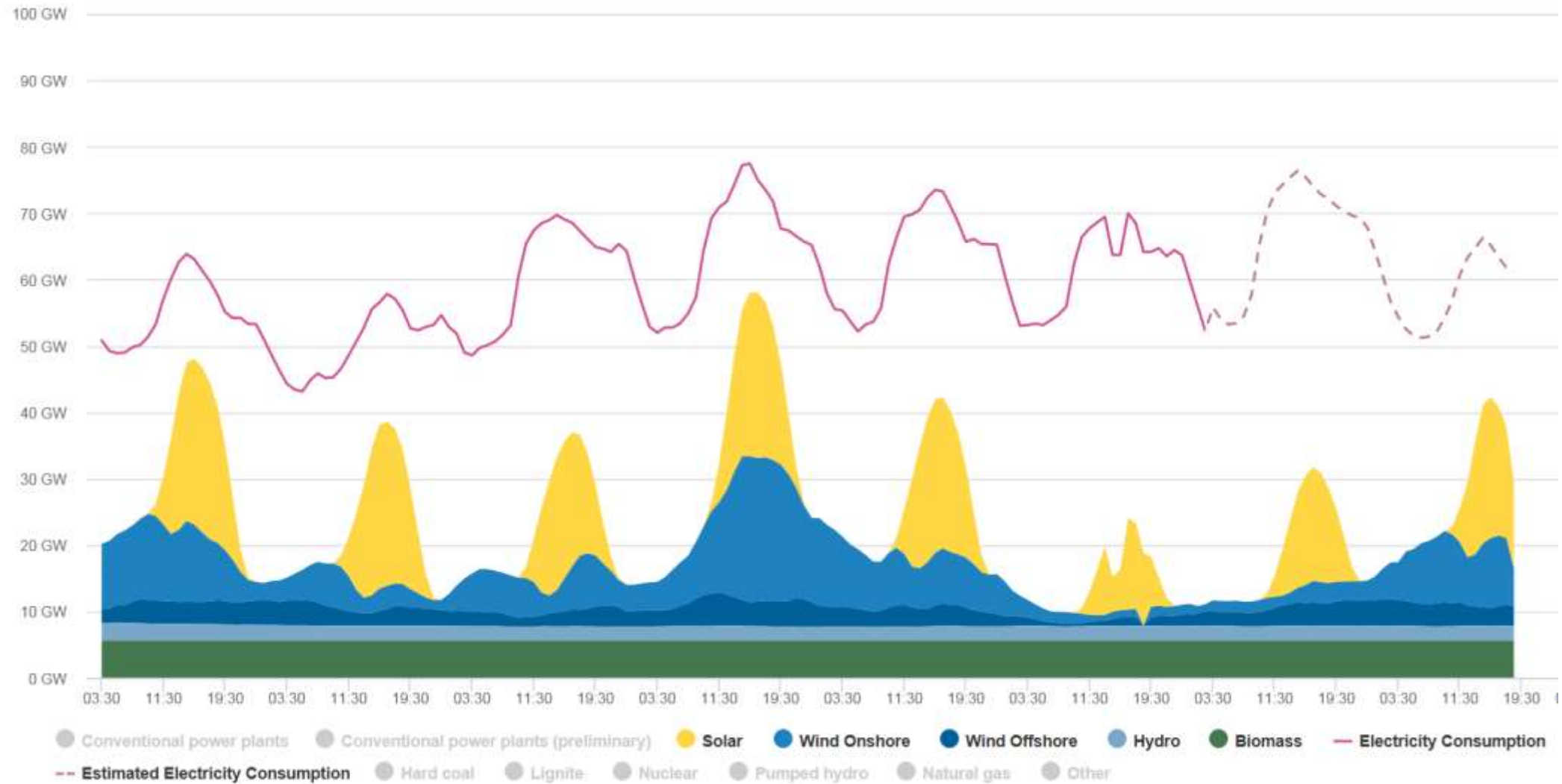
Even remaining Nuclear is being ramped up and down – See: June 22

In Germany 01/06/2021-08/06/2022



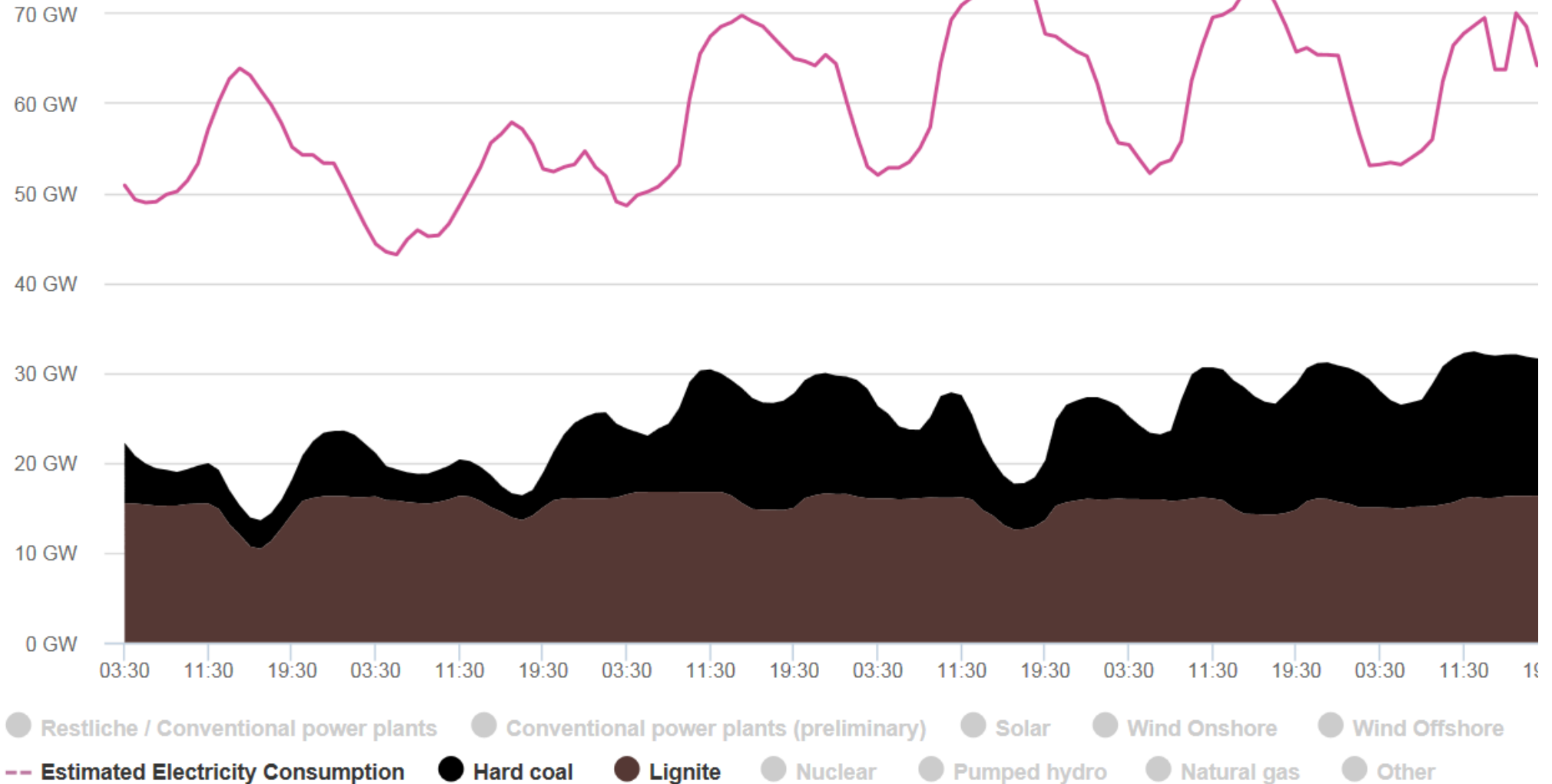
Source: Agora Energiewende, 21.11.2022

Renewables and load in Germany – a week in September



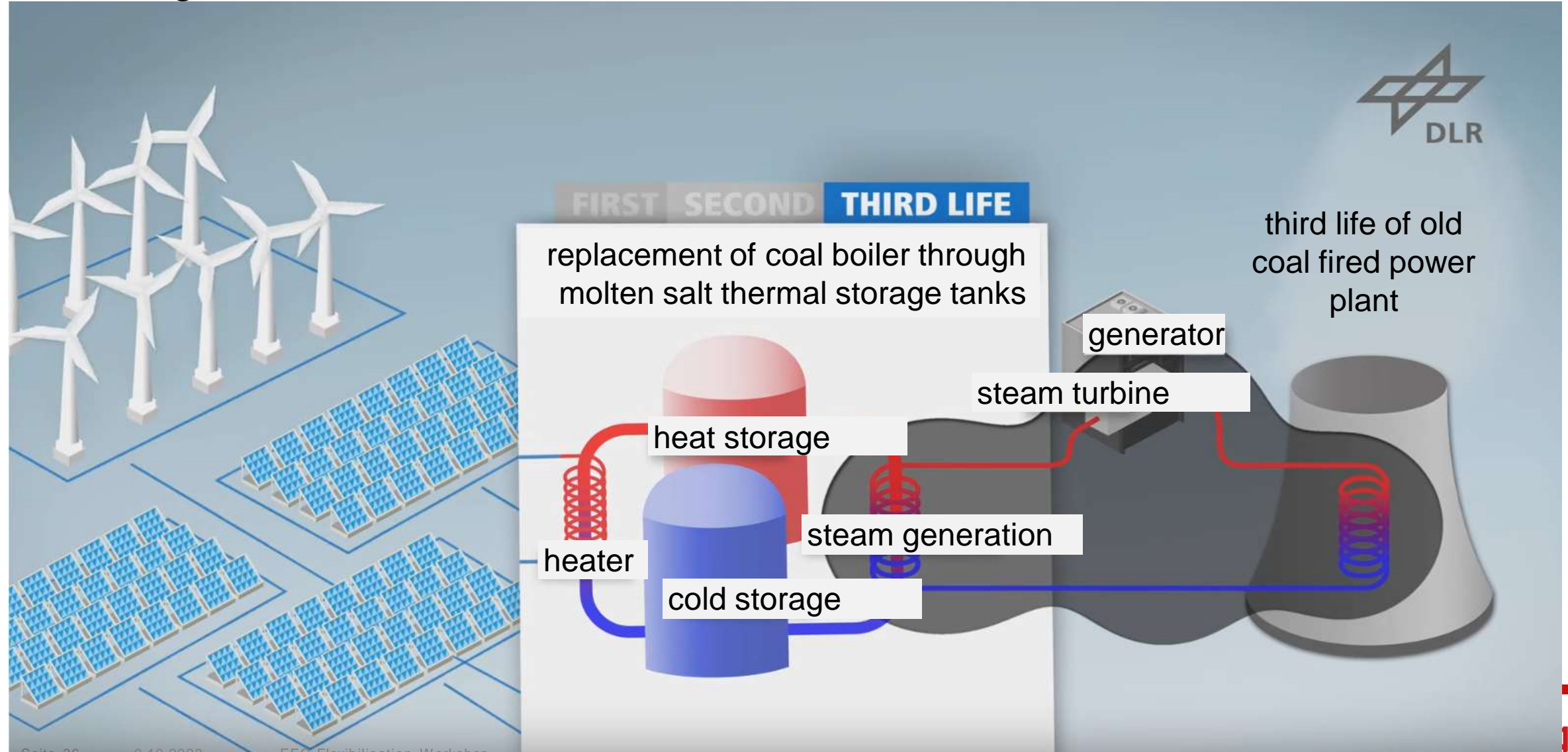
Coal and load in Germany – same week in September

The time of BASELOAD HAS ENDED



India requires GW-scale +6h power storage solution

Research in Germany and Chile ongoing by DLR with conversion of coal fired power plants into Storage



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