Optimierter Speicherbedarf für 100% erneuerbaren Strom

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Vortragender: Wolfgang Richter

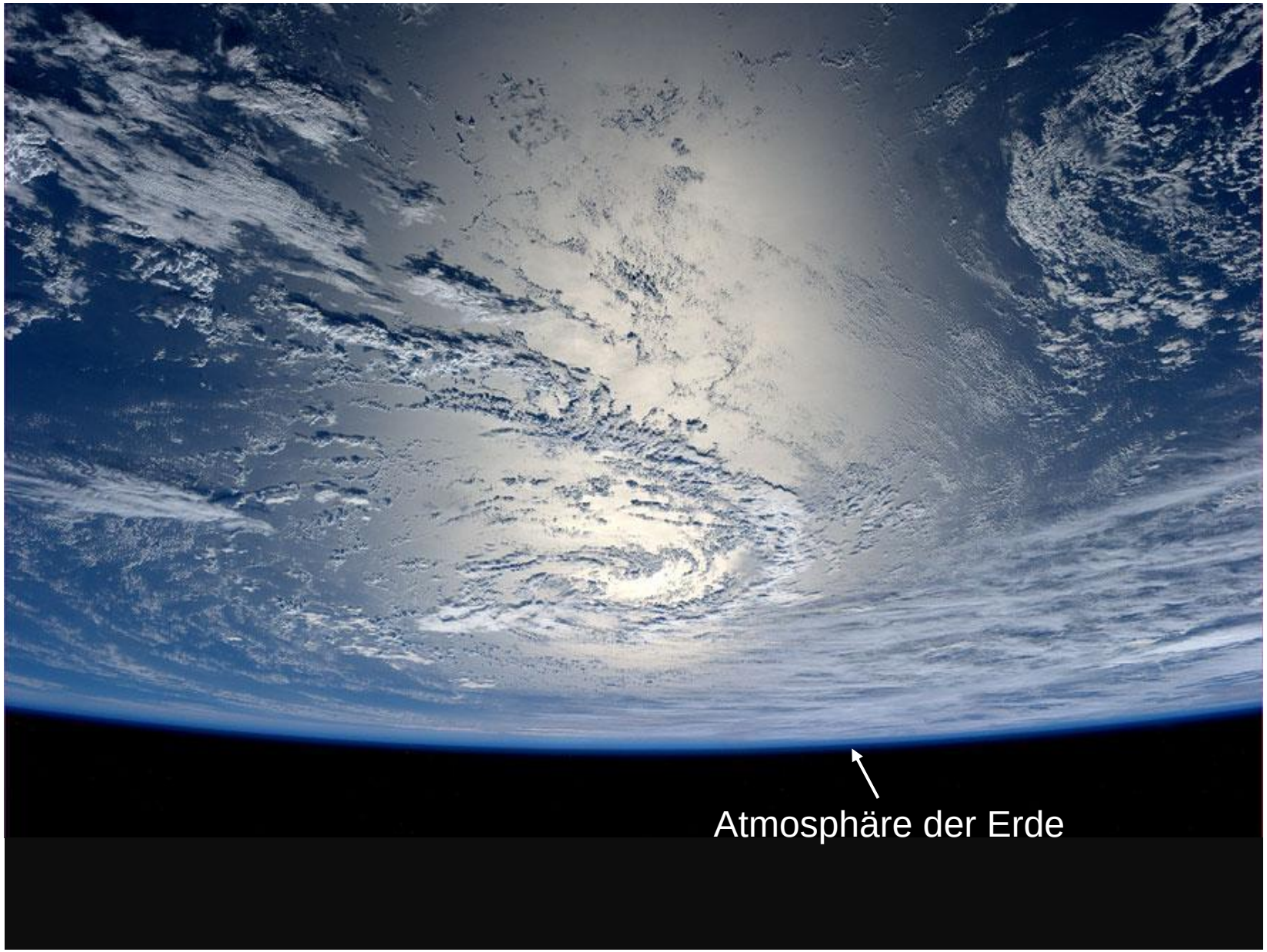
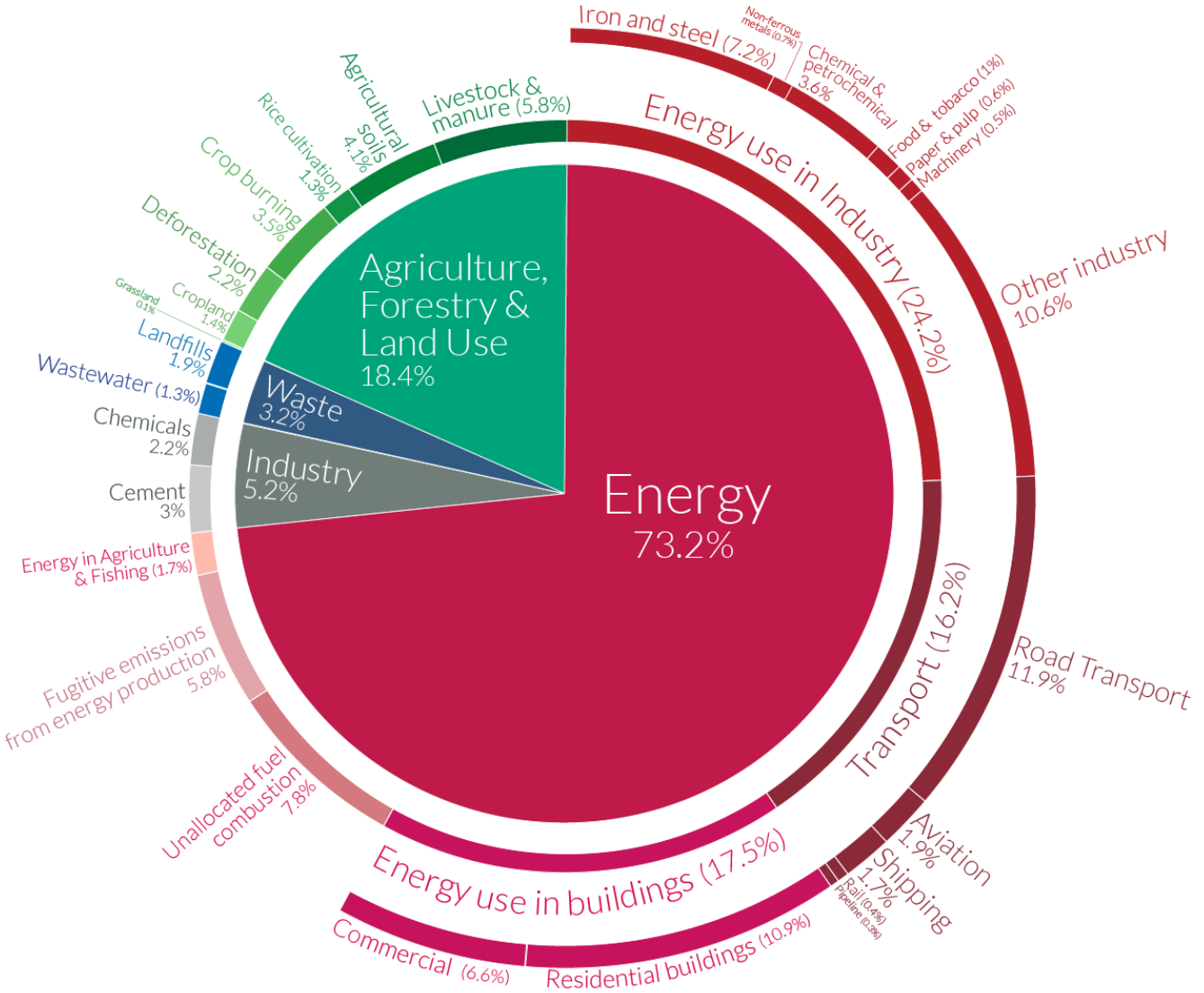


Foto: A. Gerst /ESA

Global greenhouse gas emissions by sector

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO_2eq.

Our World in Data

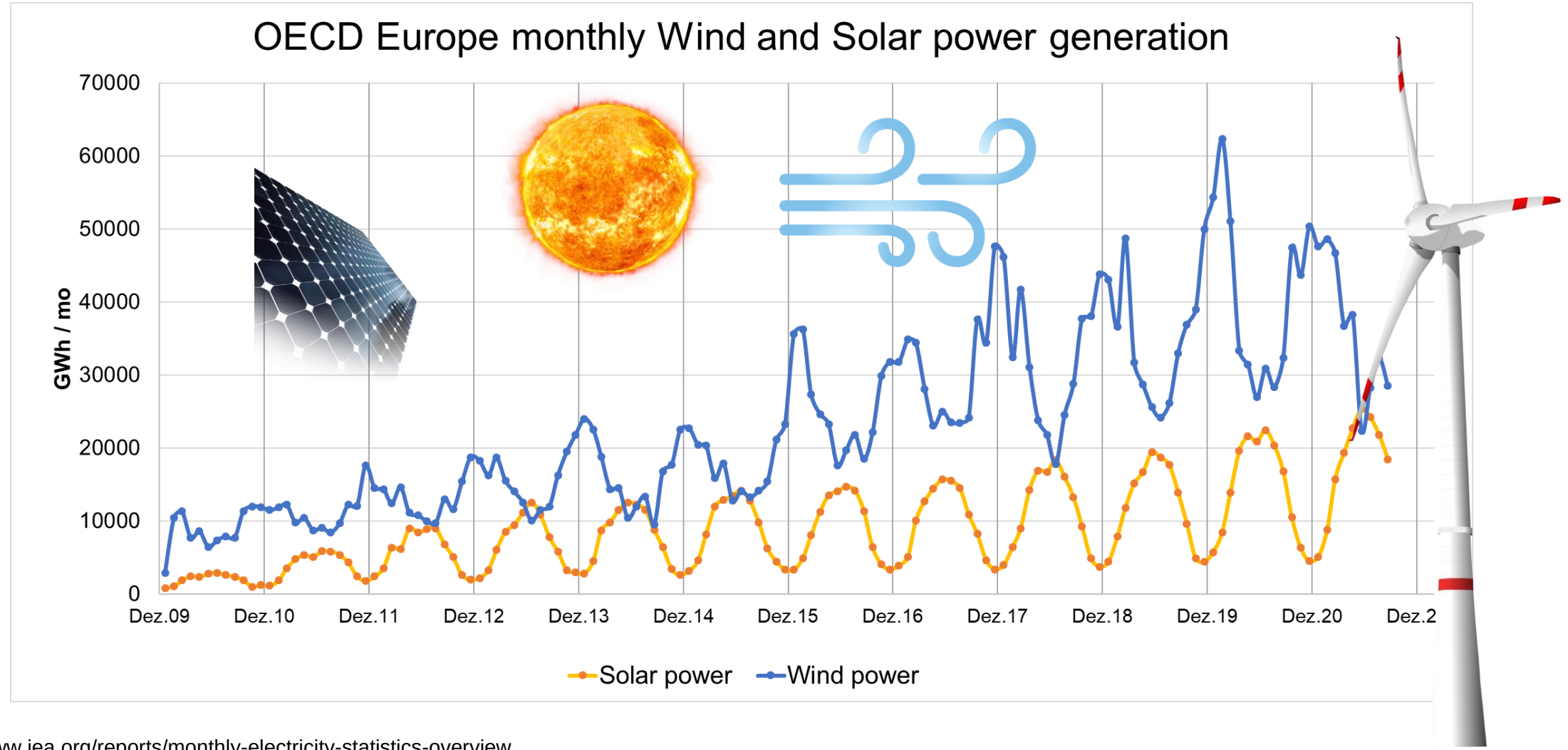


OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Climate Watch, the World Resources Institute (2020).

Lösung: Substitution der Fossilen Energie durch 100% Erneuerbare

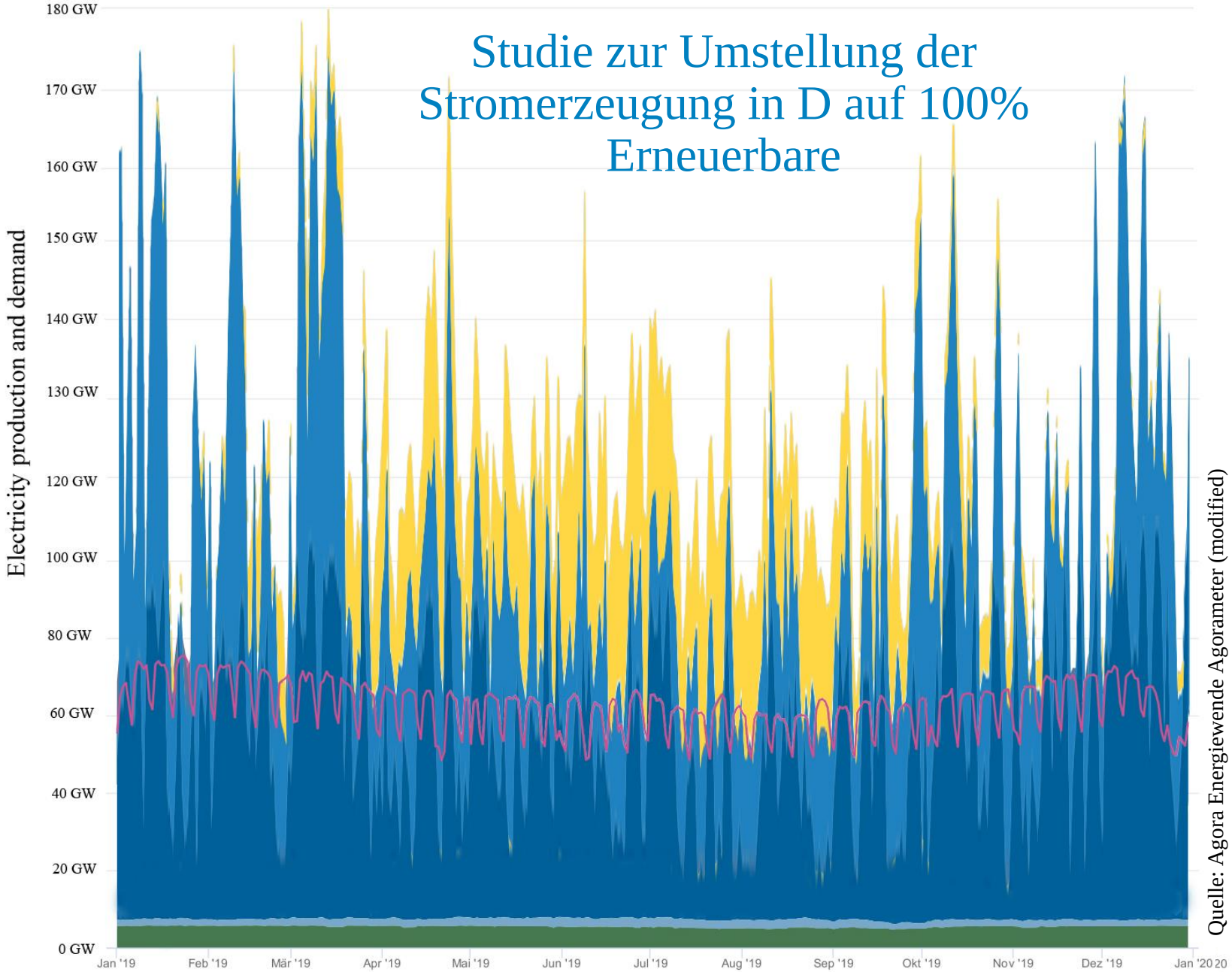
→ Elektrifizierung
→ Einsparung durch Elektrifizierung

Erneuerbare Stromerzeugung Wind und Sonne



Quelle: https://www.iea.org/reports/monthly-electricity-statistics-overview

Studie zur Umstellung der Stromerzeugung in D auf 100% Erneuerbare

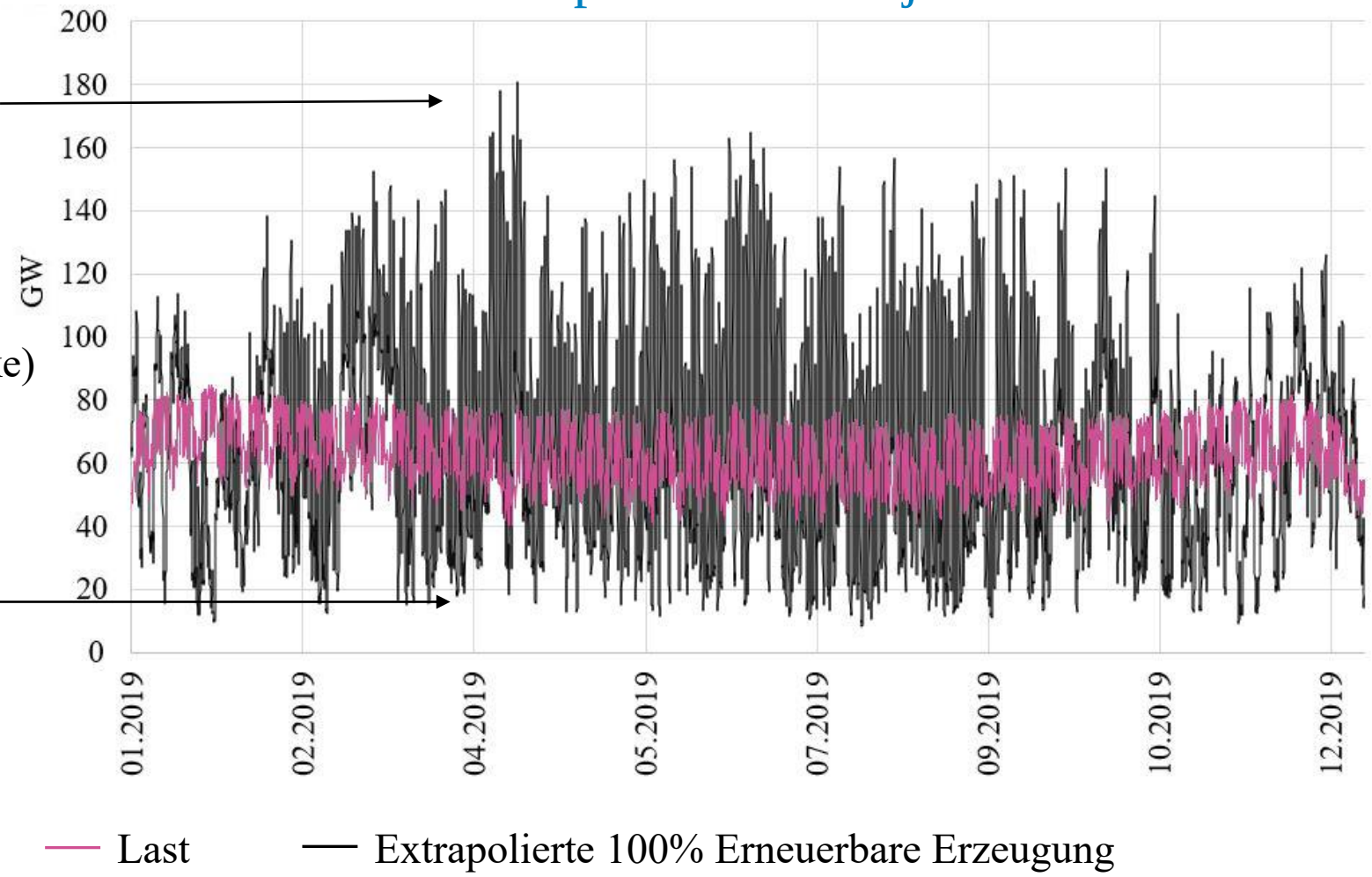


Studie zur Umstellung der Stromerzeugung in D auf 100% Erneuerbare extrapoliertes Basisjahr 2019

Über - Momentanbedarf - Erzeugung

Ausgleich über Speicher (-kraftwerke)

Unter - Momentanbedarf Erzeugung

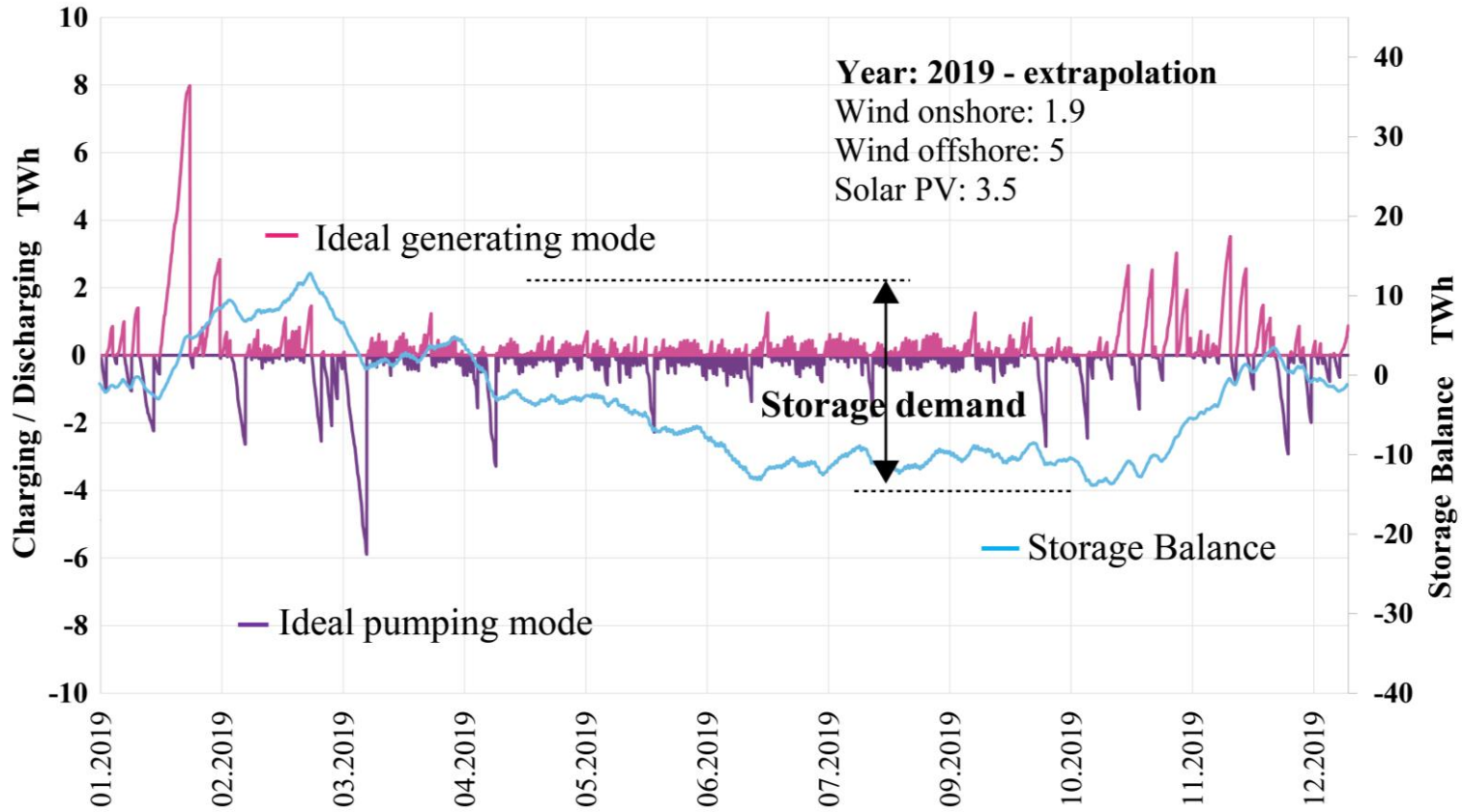


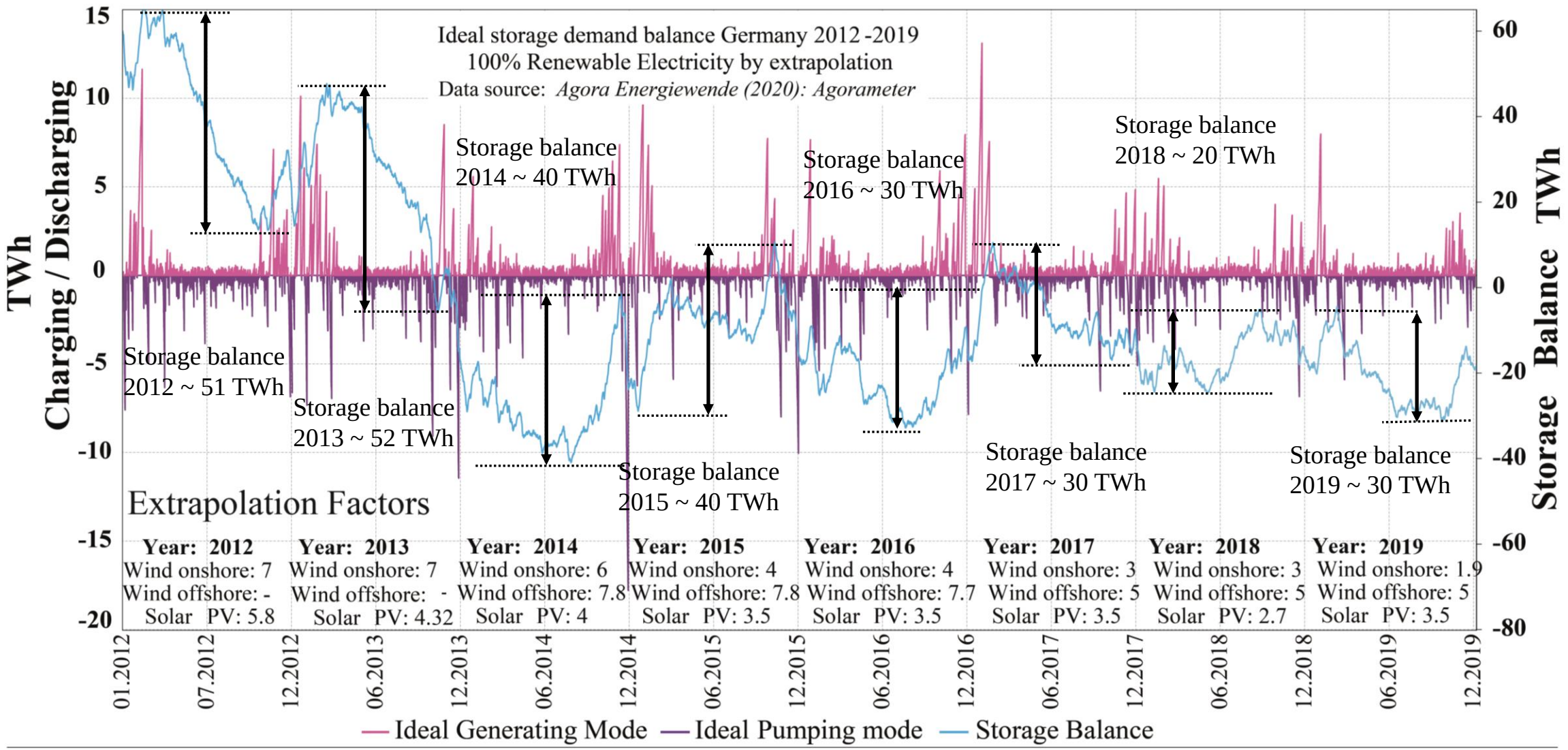
Multiplikatoren

2019:

Wind onshore: **1.9** [-]
Wind offshore: **5** [-]
Solar PV: **3.5** [-]
Wasserkraft: **1.0** [-]
Biomasse: **1.0** [-]

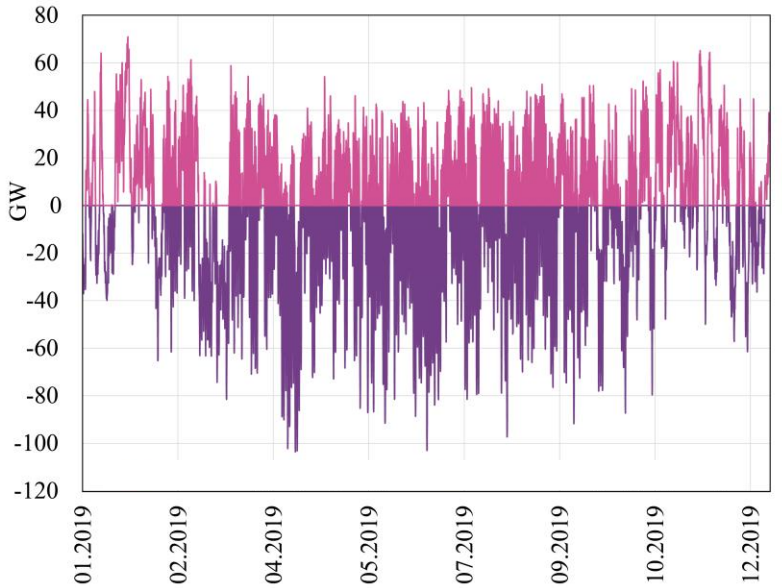
Speicher Ausgleich – extrapoliert 2019 zu 100% Erneuerbare in D




Ideal storage demand balance Germany 2012 -2019
100% Renewable Electricity by extrapolation
Data source: Agora Energiewende (2020): Agorameter
TWh Charging / Discharging
Storage Balance TWh
Storage balance 2012 ~ 51 TWh
Storage balance 2013 ~ 52 TWh
Storage balance 2014 ~ 40 TWh
Storage balance 2015 ~ 40 TWh
Storage balance 2016 ~ 30 TWh
Storage balance 2017 ~ 30 TWh
Storage balance 2018 ~ 20 TWh
Storage balance 2019 ~ 30 TWh
Extrapolation Factors
Year: 2012 Wind onshore: 7 Wind offshore: - Solar PV: 5.8
Year: 2013 Wind onshore: 7 Wind offshore: - Solar PV: 4.32
Year: 2014 Wind onshore: 6 Wind offshore: 7.8 Solar PV: 4
Year: 2015 Wind onshore: 4 Wind offshore: 7.8 Solar PV: 3.5
Year: 2016 Wind onshore: 4 Wind offshore: 7.7 Solar PV: 3.5
Year: 2017 Wind onshore: 3 Wind offshore: 5 Solar PV: 3.5
Year: 2018 Wind onshore: 3 Wind offshore: 5 Solar PV: 2.7
Year: 2019 Wind onshore: 1.9 Wind offshore: 5 Solar PV: 3.5
01.2012
07.2012
12.2012
06.2013
12.2013
06.2014
12.2014
06.2015
12.2015
06.2016
12.2016
06.2017
12.2017
06.2018
12.2018
06.2019
12.2019
Ideal Generating Mode
Ideal Pumping mode
Storage Balance

Bedarf Leistung

Ideal → asymmetrisch



Turbinieren / Entladen

Pumpen / Laden

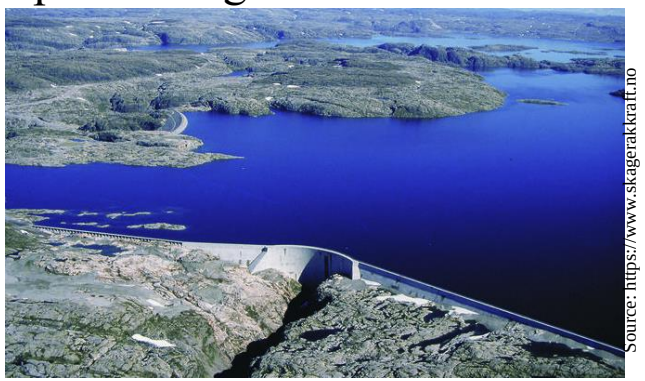
Pumpspeicher → symmetrisch
Wirkungsgrad: ~ 80%

www.nsenergybusiness.com, PSH La Muela II; Spain

η: PSKW ~ 80%

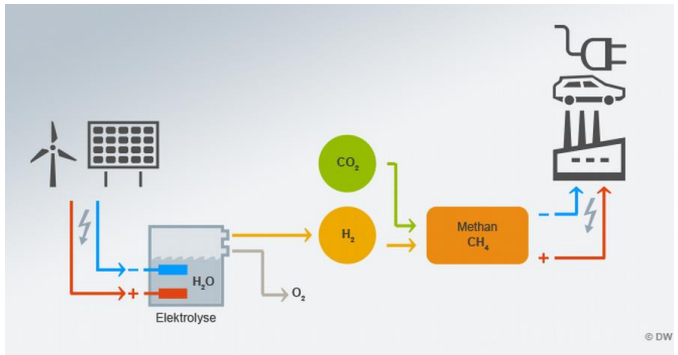
Pumpspeicher + Wasserspeicher
reservoir → assymmetrisch
η: Hydro ~ 90%
Interkonnektoren - passive
Speicherung -

&



Source: https://www.skagerakkraft.no

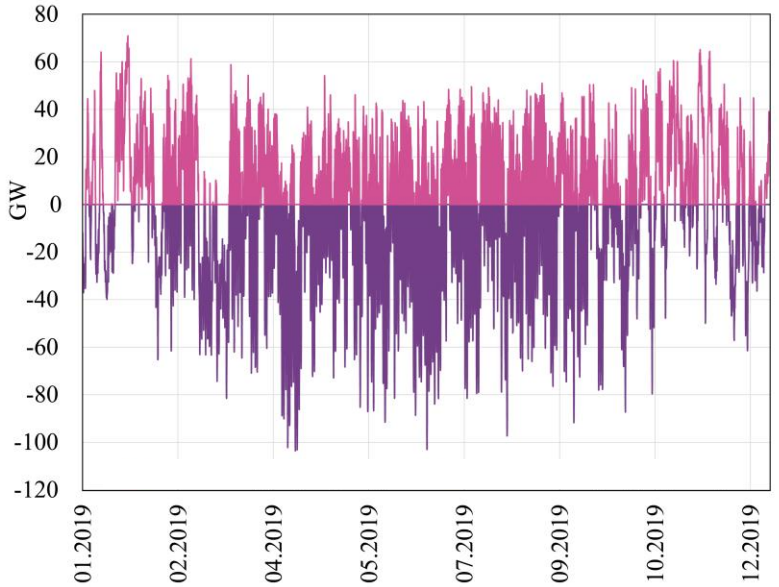
Power to Gas to Power → asymmetrisch
Wirkungsgrad: ~28%



Source: www.dw.com

Bedarf - Leistung

Ideal → asymmetrisch

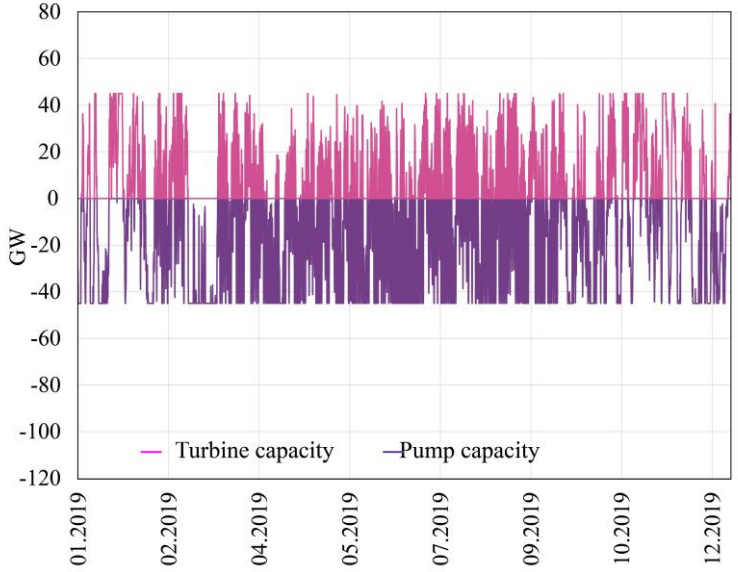


Turbinenbetrieb / Entladen

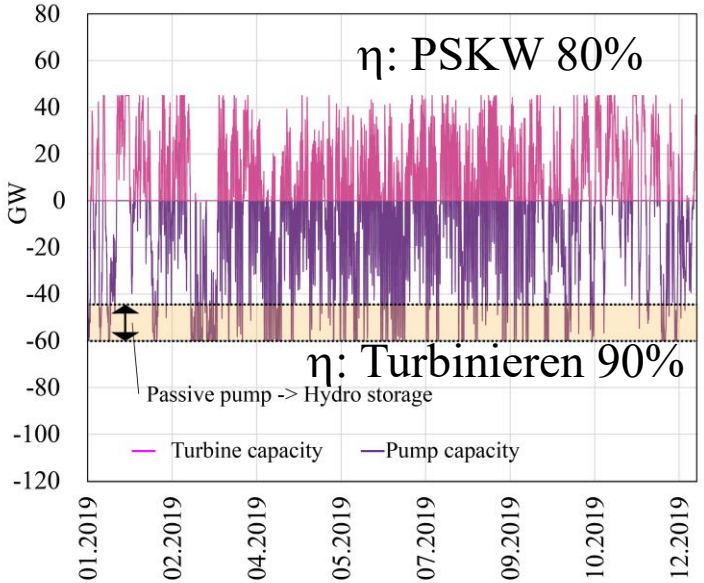
Pumpen / Laden

Pumpspeicher → symmetrisch

Wirkungsgrad: 80%

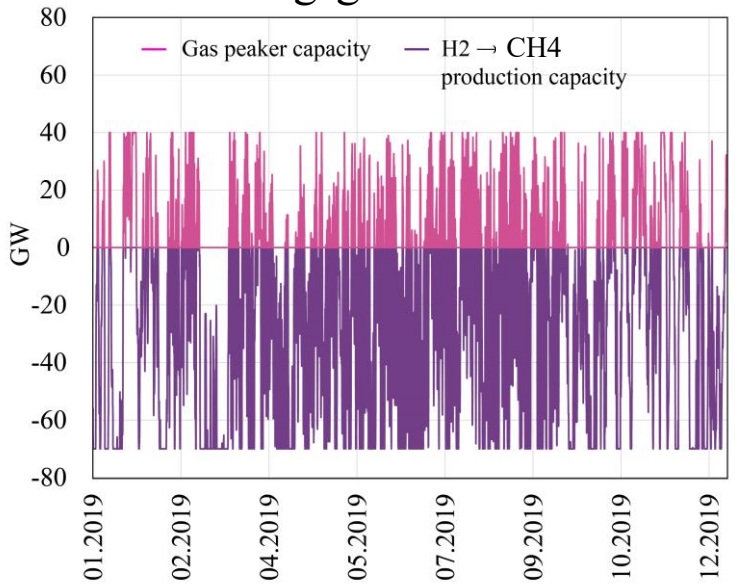


Pumpspeicher + Wasserspeicher → asymmetrisch

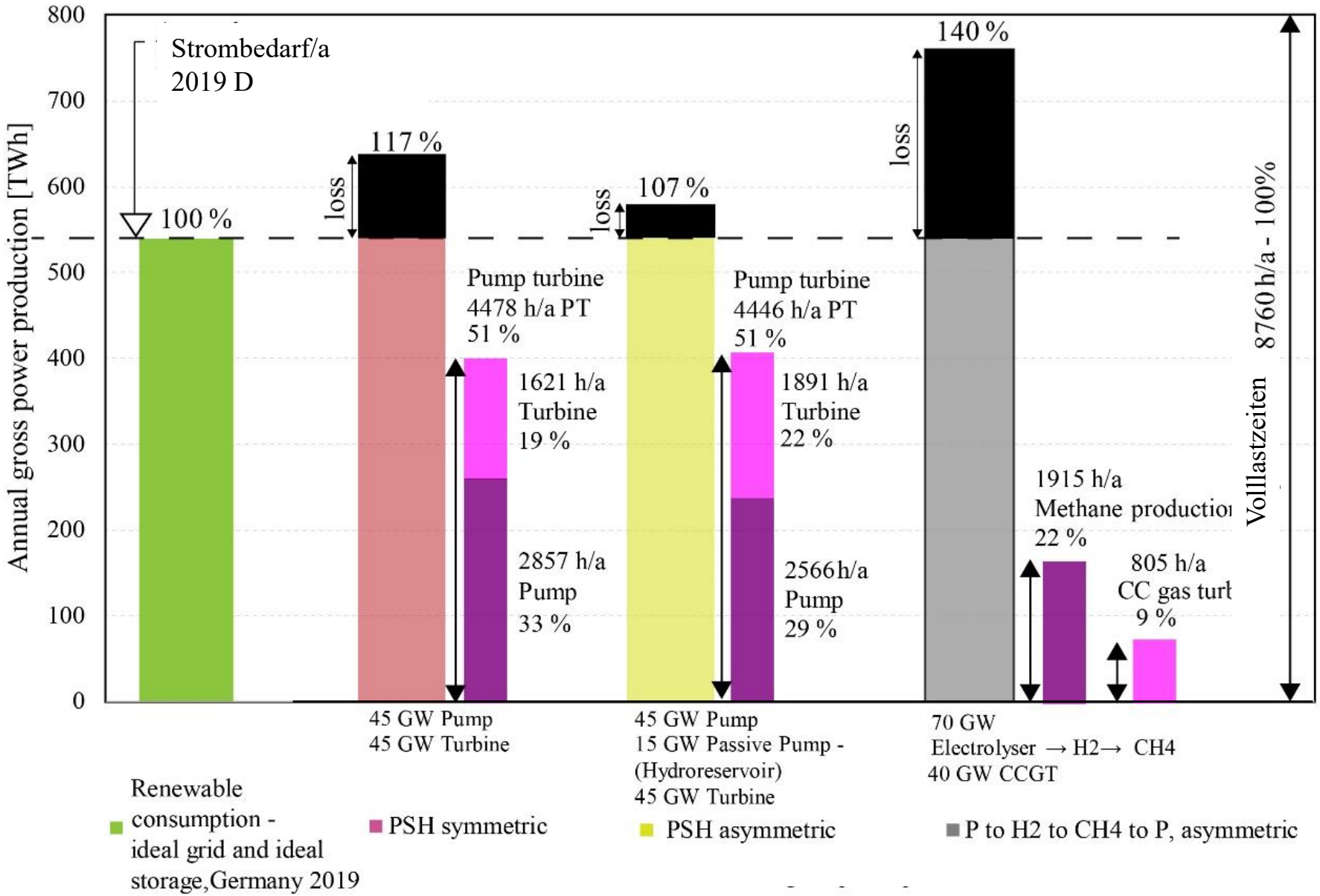


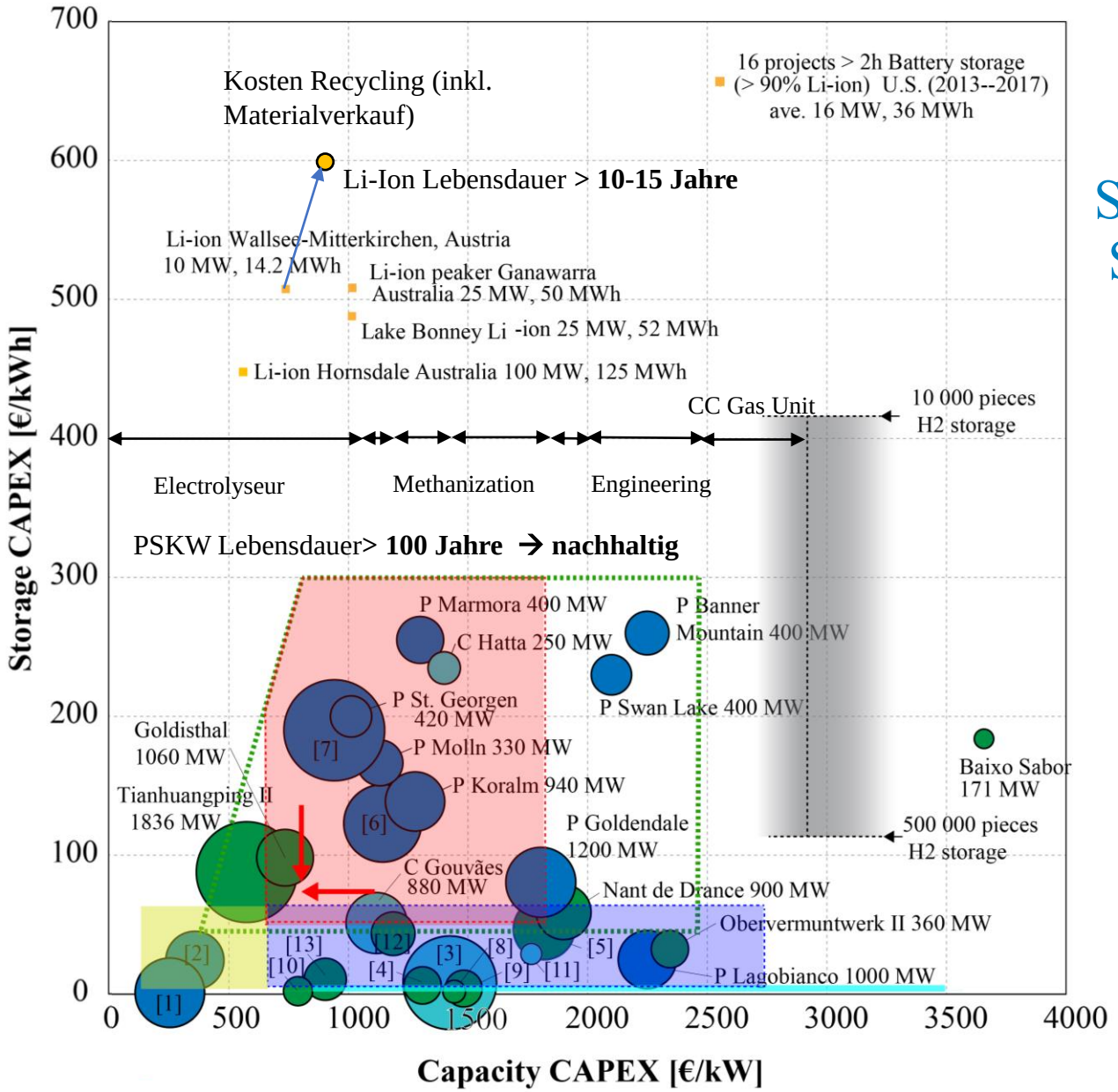
Power to Gas → asymmetrisch

Wirkungsgrad: 28%



100 % Erneuerbarer Strom– Speicher Vergleich





Spezifische Invest. Kosten € / Leistung kW
Spezifische Invest. Kosten € / Speicher kWh

C ... in Construction

P ... Project

In Operation or in commissioning

Upgrade and new complete PSH in Norway, global optimal sites

UPSH specific cost reduction by increase of storage volume resp. larger energy content and increased head

New PSH with new reservoirs

Upgrade of PSH – existing reservoirs

UPSH Underground pumped-storage hydropower

P to H2 to CH4 to P, Plant facility

PSH in Norway

[1] ... P Kuli, 1300 MW, 300 GWh

[2] ... P Tonstad 960 MW

[3] ... C Snowy 2.0 2000 MW

[4] ... Kopswerk II 360 MW

[5] ... Linthal 2015, 1000 MW

[6] ... P Atdorf 1400 MW

[7] ... P Attaqa Mountain 2400 MW

[8] ... Duge 170 MW

[9] ... Saurdal 320 MW

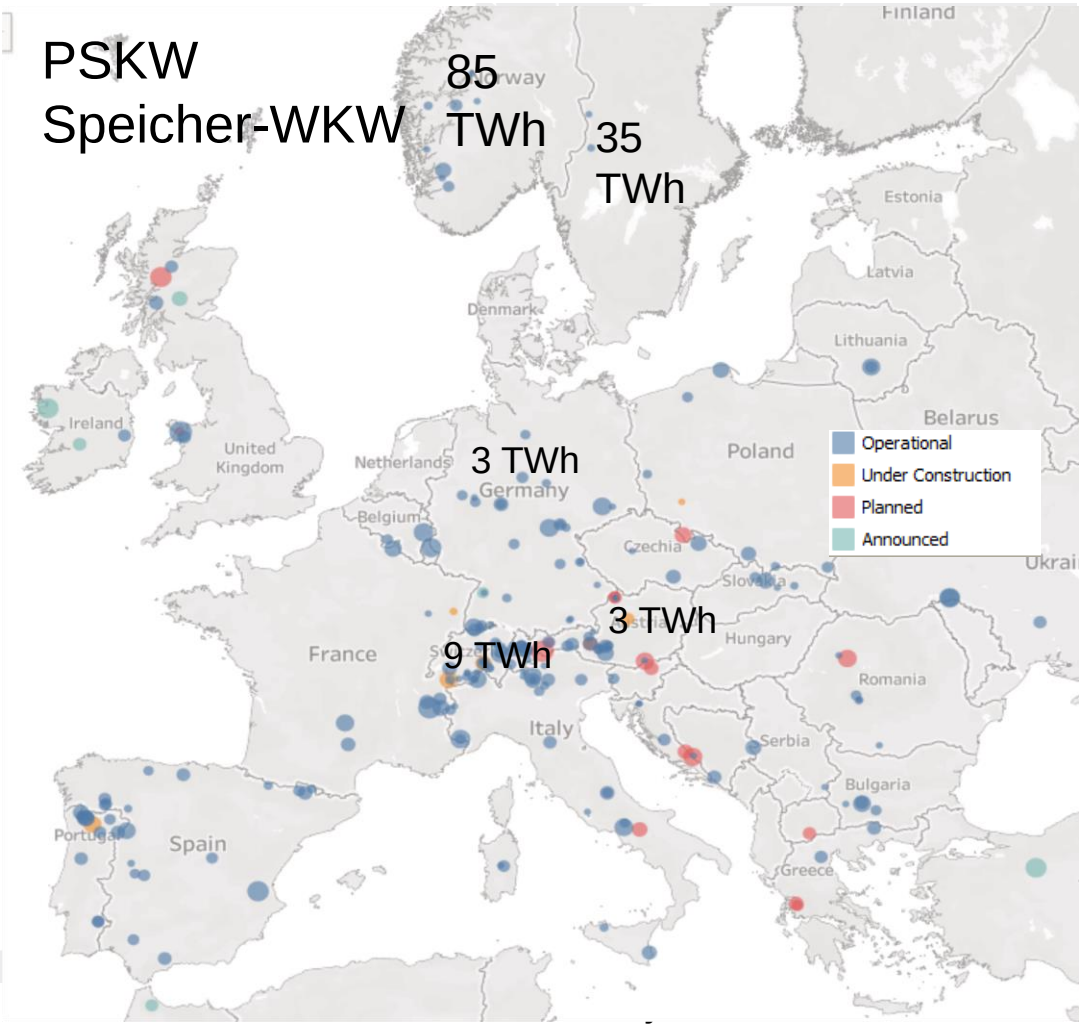
[10] ... Aurland III 258 MW

[11] ... C Tauernmoos 170 MW

[12] ... Reisseck II 430 MW

[13] ... Limberg II 480 MW

Interkonnektoren und Europäischer Erzeugungs & Speicherausgleich



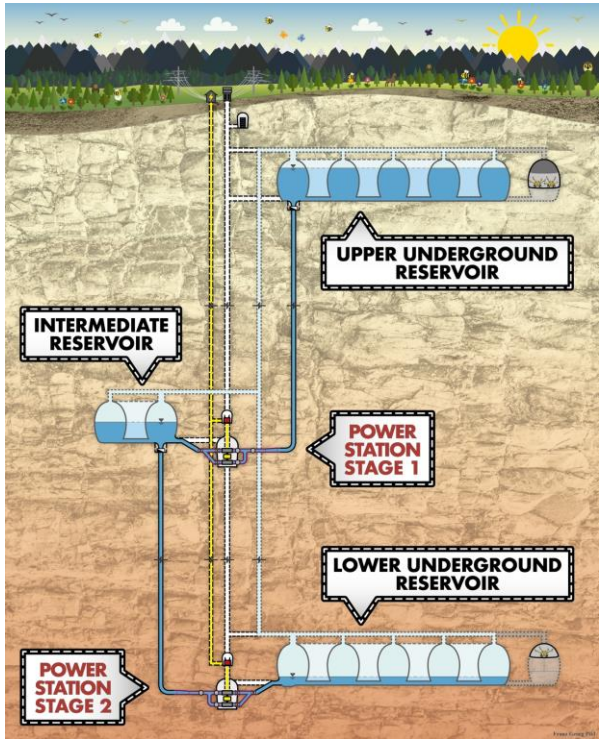
Source: ENTSO-E's 10-year network development [24]

Source: https://www.skagerakkraft.no

Speicherwasserkraft & Pumpspeicher

© Pikl F.G.. ATCOLD 2018 Pumped Storage Hydropower in Austria

Untertage - PSKW



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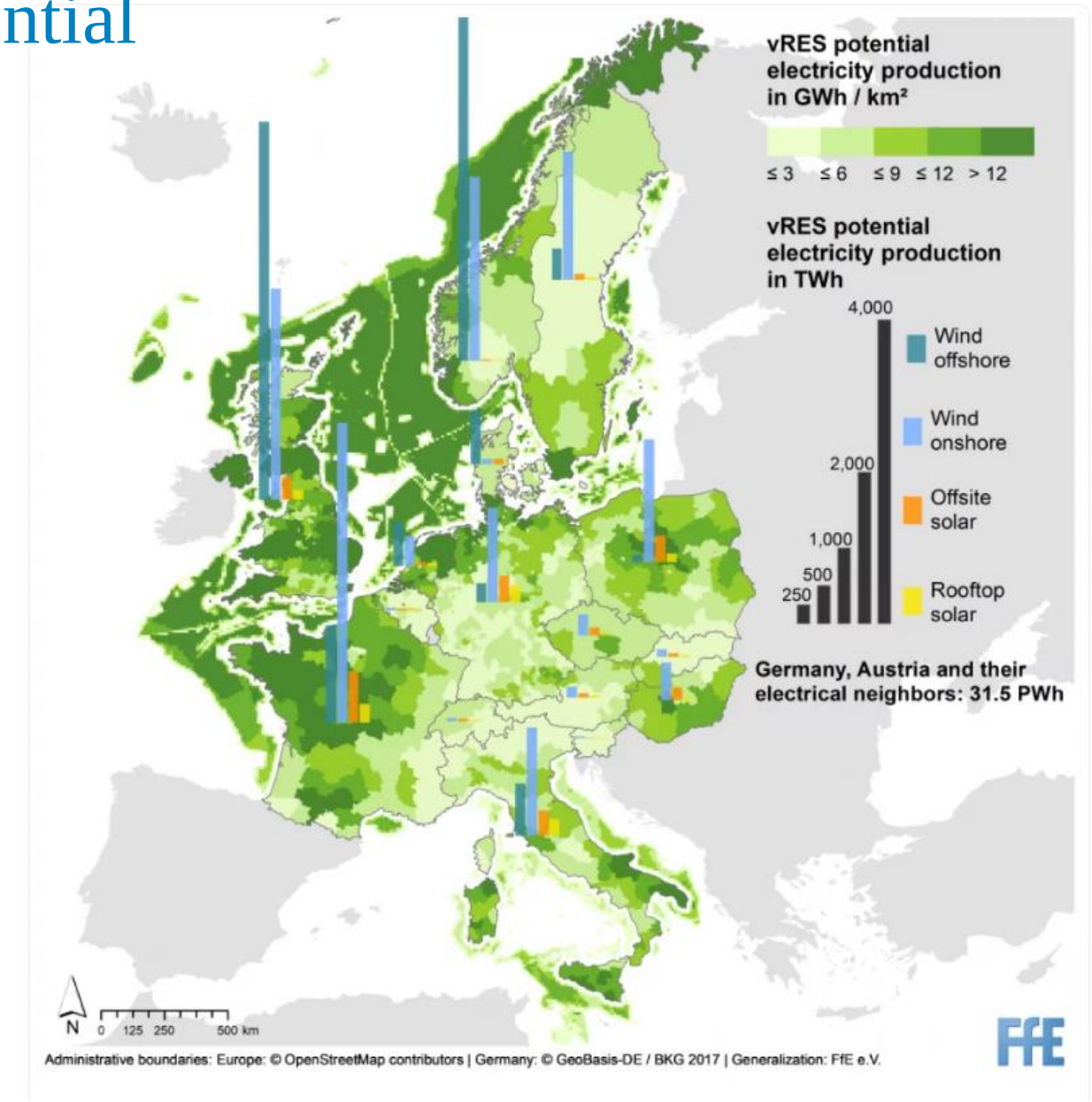
Erneuerbares Potential in Europa



31500 TWh
Wind und Solar Potential

Quelle: https://www.ffe.de/veroeffentlichungen/regionalisierte-potenzialanalyse-erneuerbarer-energien-in-europa/

Zusammenfassung

- Sonnen- und Windkraft = komplementäre Erzeugung über Jahreszeiten
- Optimierung des Stromspeicherbedarf durch abgestimmtem Erneuerbaren Ausbau
- Speicherbedarf für D (2019)- ~ 5% des jährlichen Strombedarf (ideale Randbedingungen)
- Speicherwasserkraft kombiniert mit Pumpspeicherkraft
  - Effizienteste Großspeicher (-kraftwerke)
  - Geringste Dissipationsverluste
- PtGtP: Hohe Umwandlungsverluste
- PtGtP geringe Volllastzeiten an unterschiedlichen Einheiten
- Notwendig:
  - Massiver Ausbau der Erneuerbaren in Europa – insb. Wind- und Sonnenkraft
  - Europäische Energie-Souveränität
  - Ausbau eines leistungsfähigen europäischen Stromnetzes
  - Ausbau effizienter Stromspeicher
  - Europaweite Nutzung und Vernetzung der Erneuerbaren Potentiale
  - 100% erneuerbare Erzeugung für 100% erneuerbare Endenergie
  - Elektrifizierung der Sektoren Transport + Wärme

Vielen Dank für die Aufmerksamkeit

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