



# OPTIMIERTER SPEICHERBEDARF FÜR 100% ERNEUERBAREN STROM

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**EnInnov2022**

**17. Symposium Energieinnovation | 16.02.–18.02.2022**

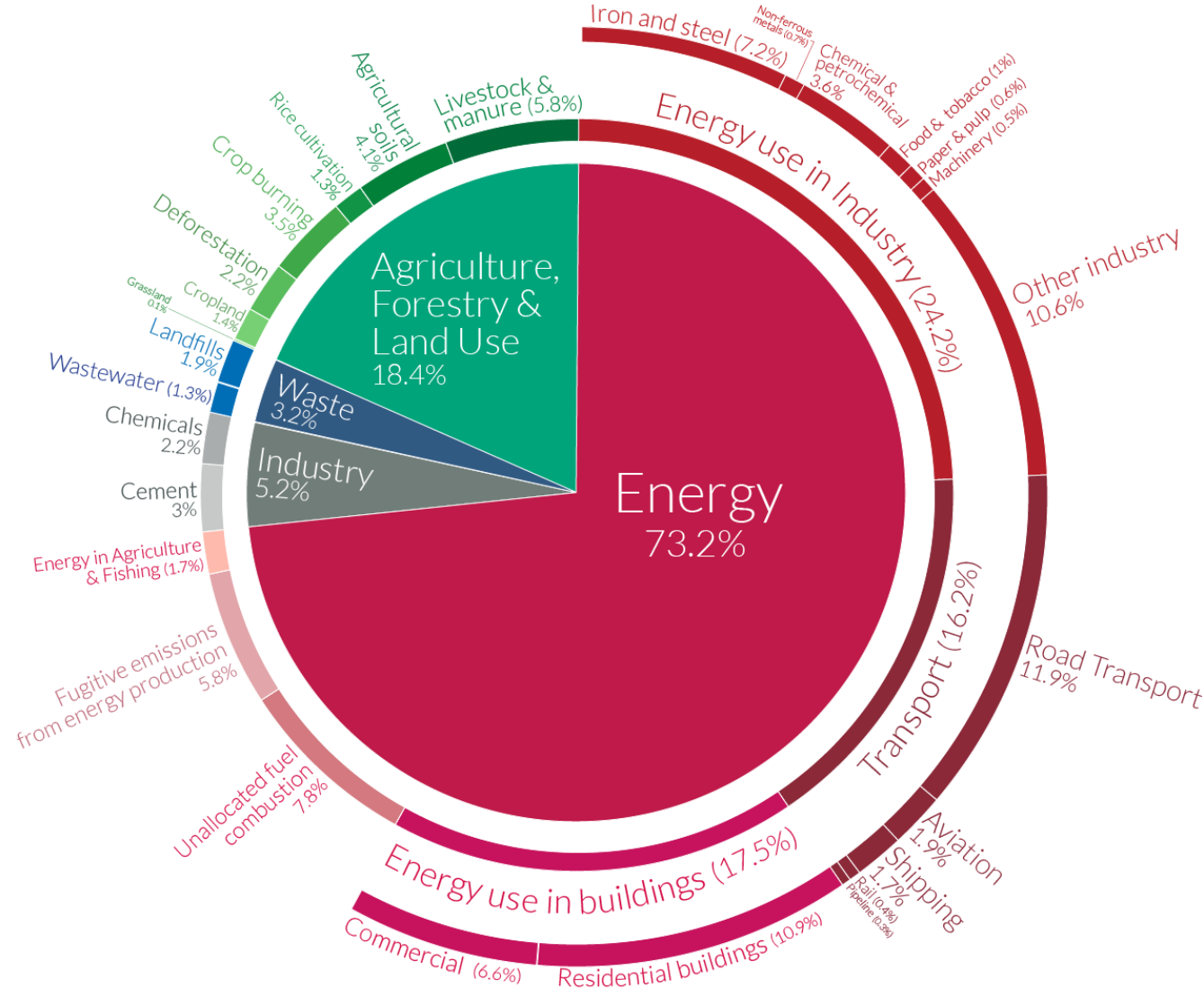


Atmosphäre der Erde

# Global greenhouse gas emissions by sector

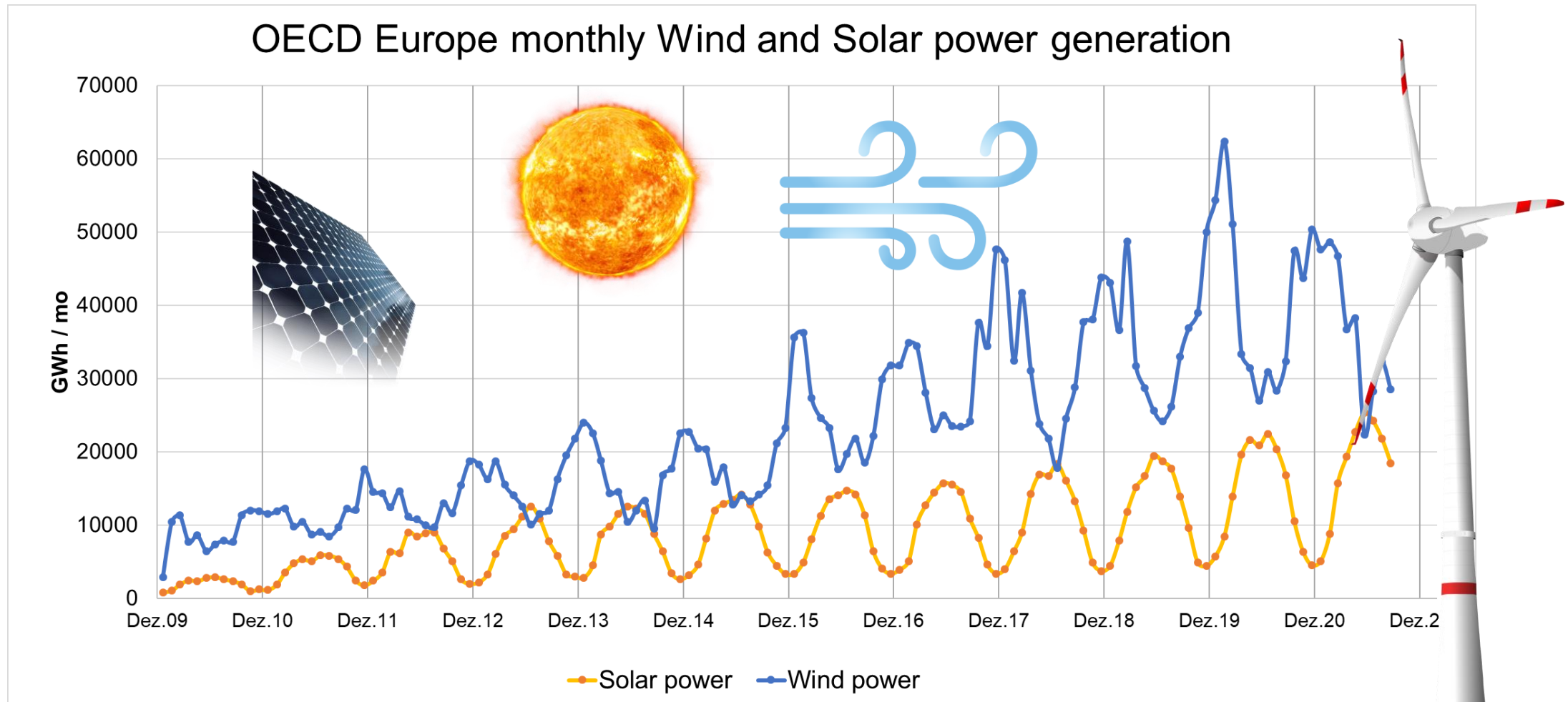
Our World in Data

This is shown for the year 2016 – global greenhouse gas emissions were 49.4 billion tonnes CO<sub>2</sub>eq.

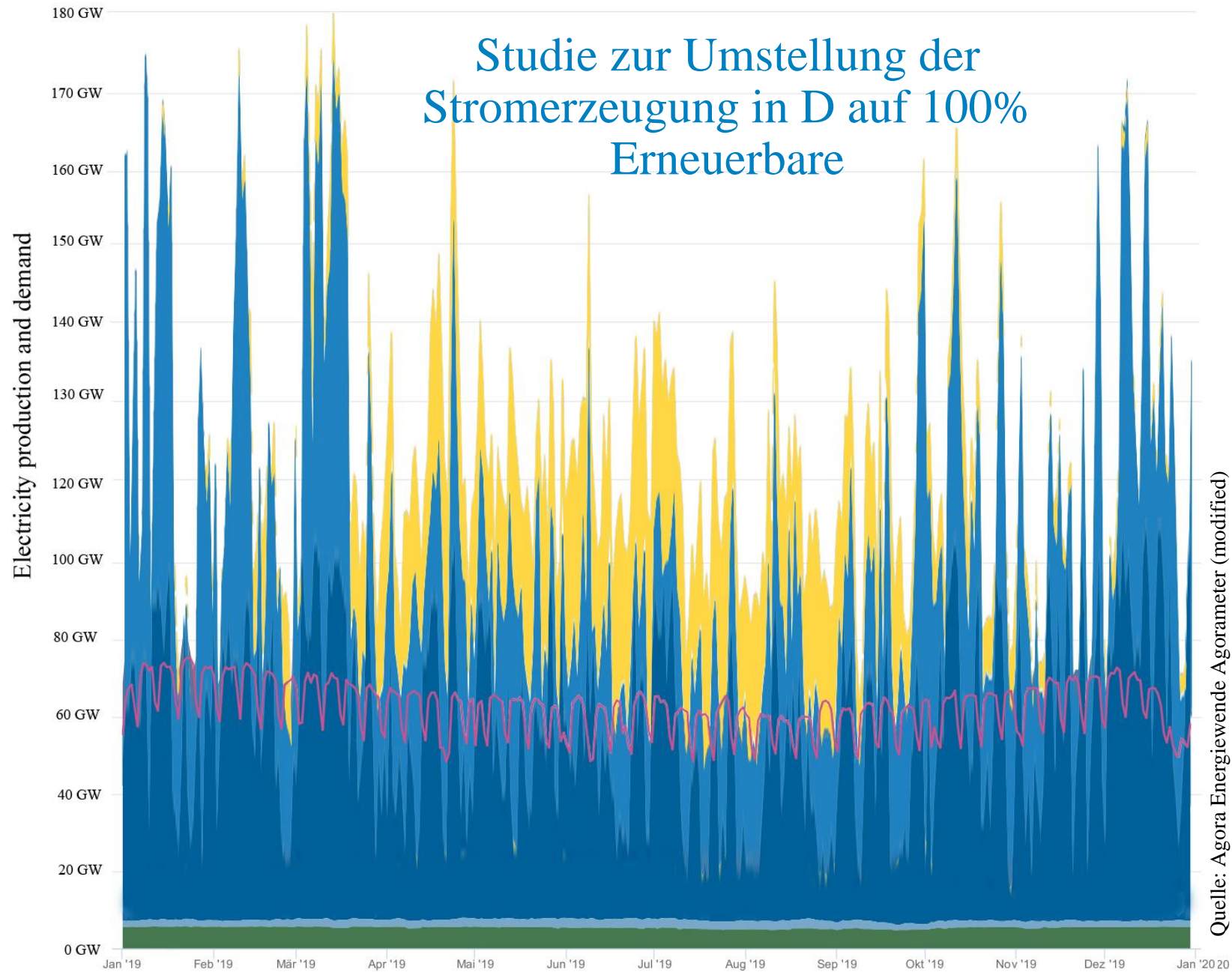


Lösung:  
 Substitution der Fossilen Energie durch 100% Erneuerbare  
 → Elektrifizierung  
 → Einsparung durch Elektrifizierung

# Erneuerbare Stromerzeugung Wind und Sonne

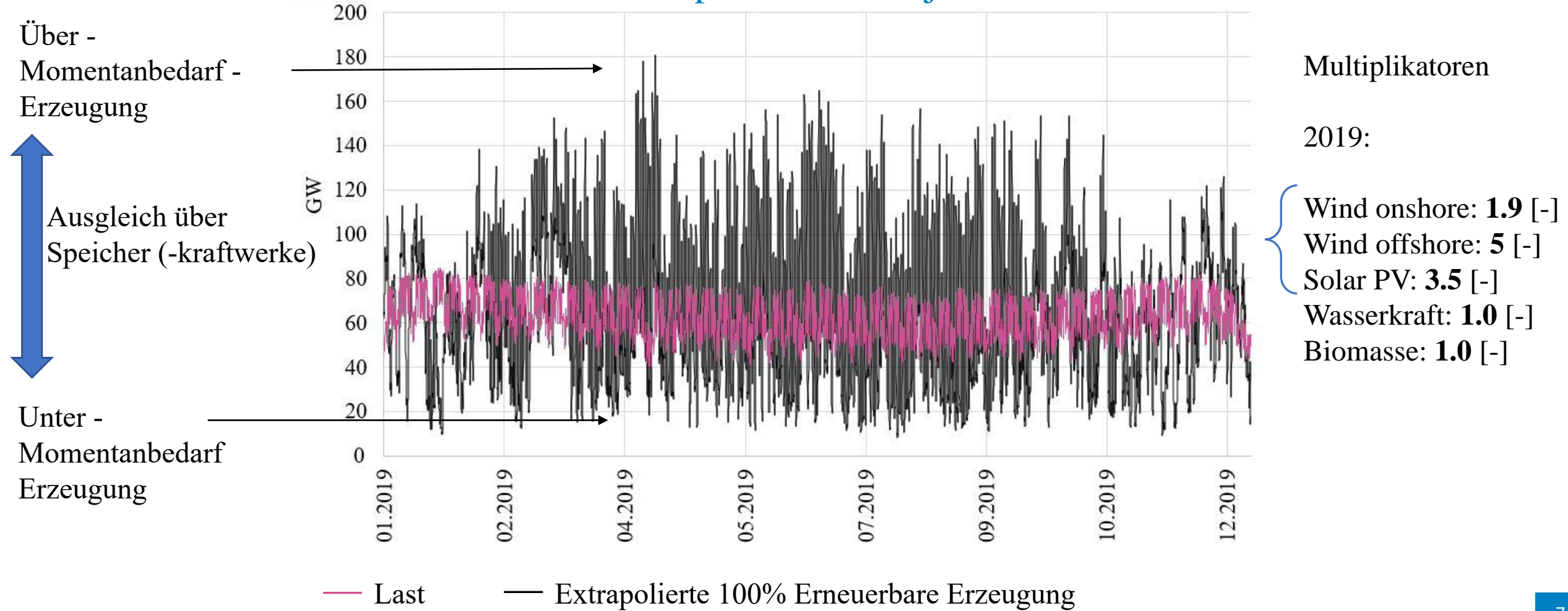


# Studie zur Umstellung der Stromerzeugung in D auf 100% Erneuerbare

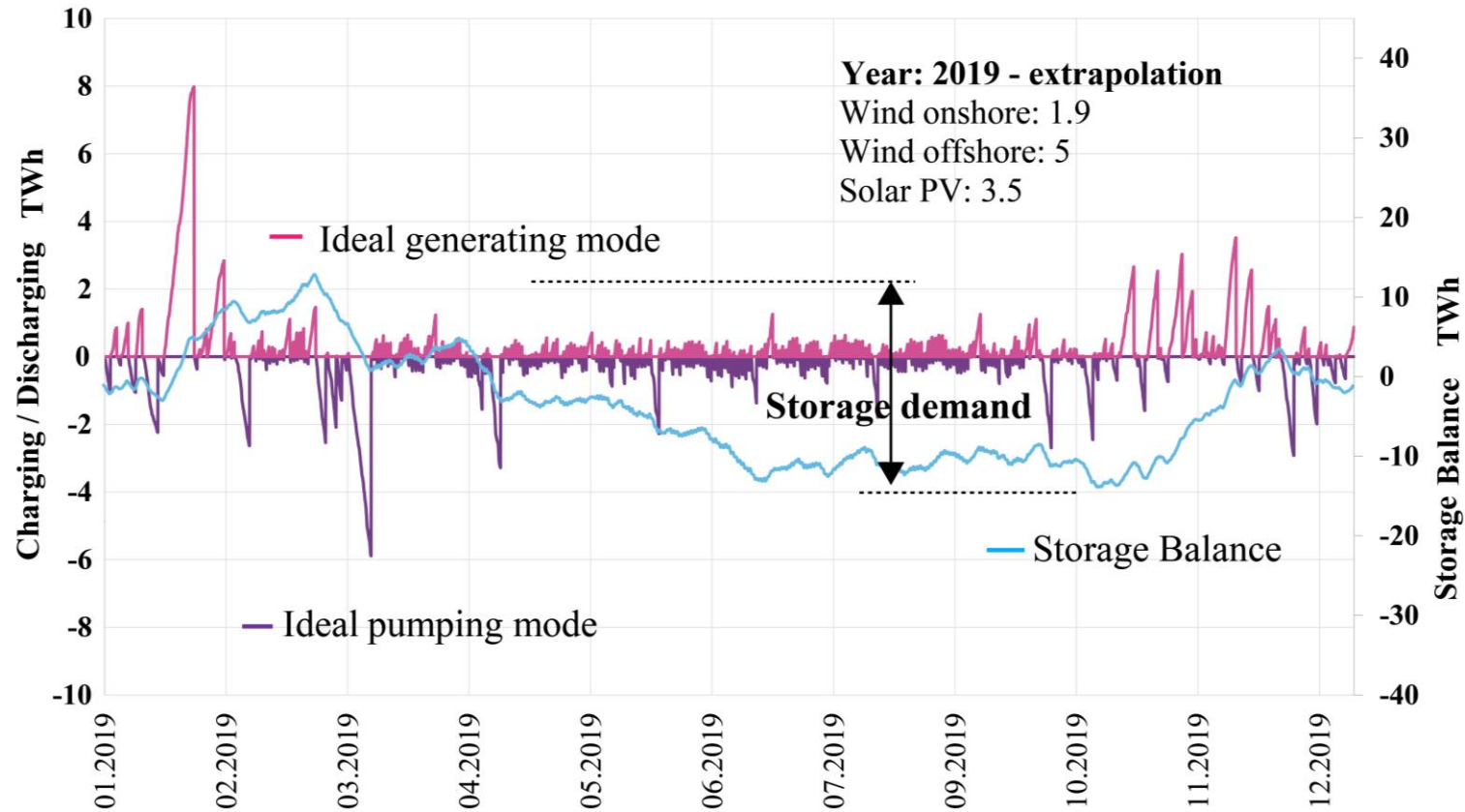


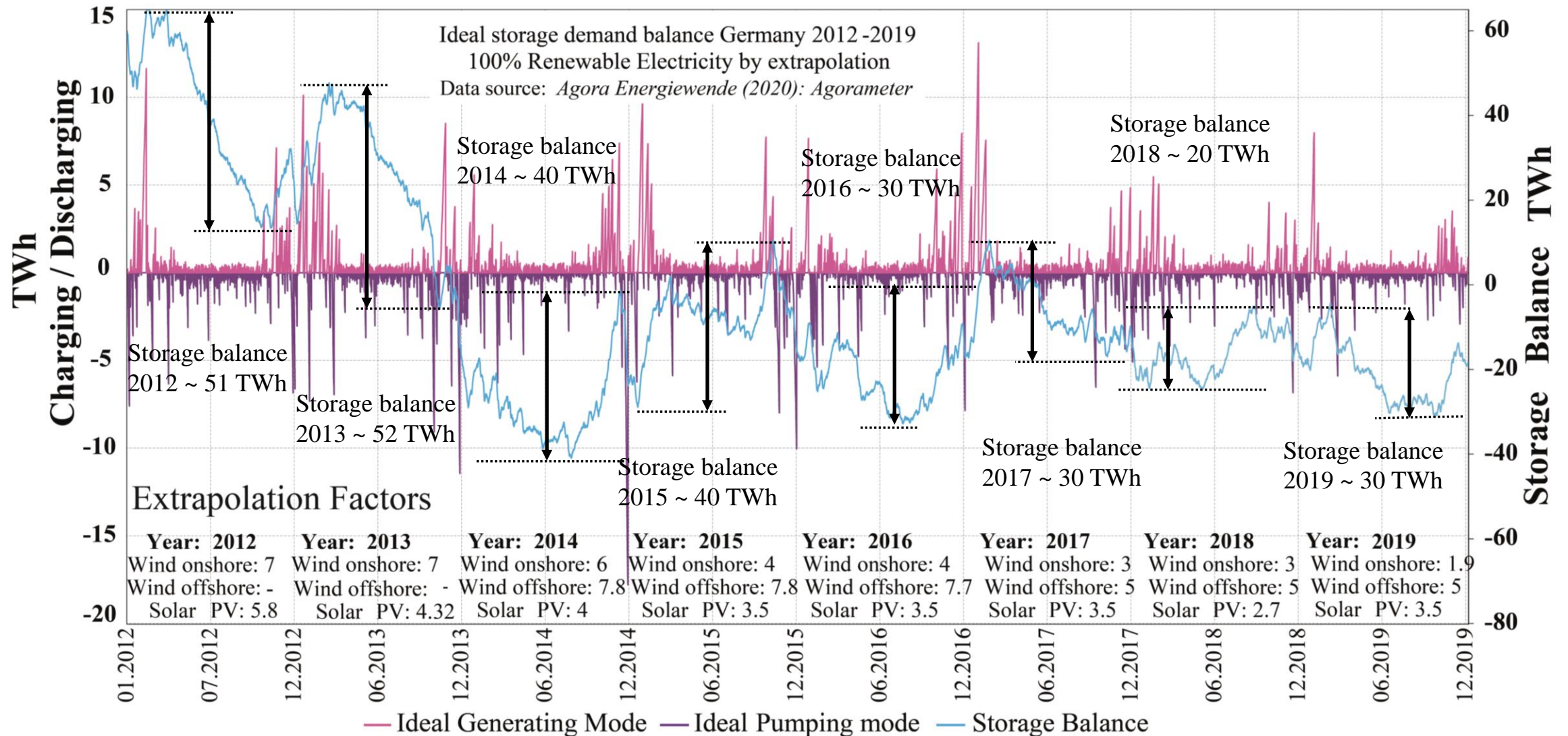
Quelle: Agora Energiewende Agorameter (modified)

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



# Speicher Ausgleich – extrapoliert 2019 zu 100% Erneuerbare in D

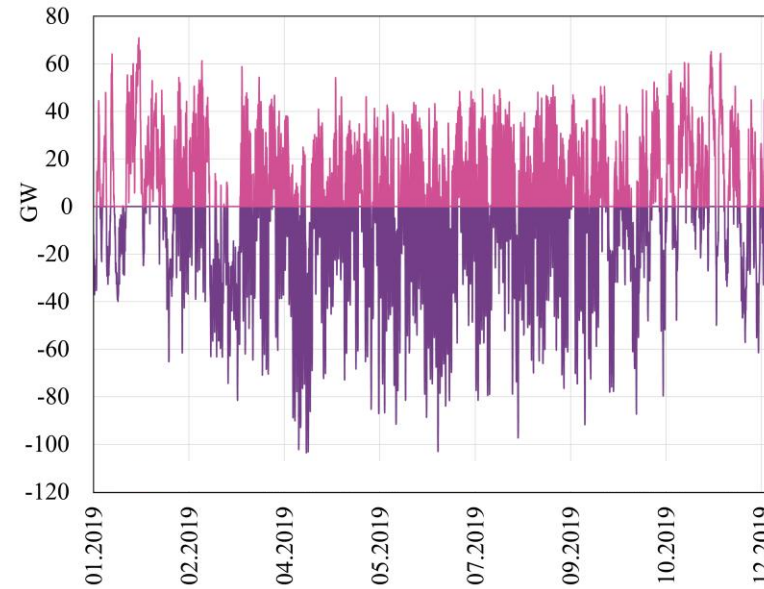






# Bedarf Leistung

Ideal →  
asymmetrisch



— Turbinieren / Entladen

— Pumpen / Laden

Pumpspeicher → symmetrisch  
Wirkungsgrad: ~ 80%

Pumpspeicher + Wasserspeicher  
reservoir → asymmetrisch

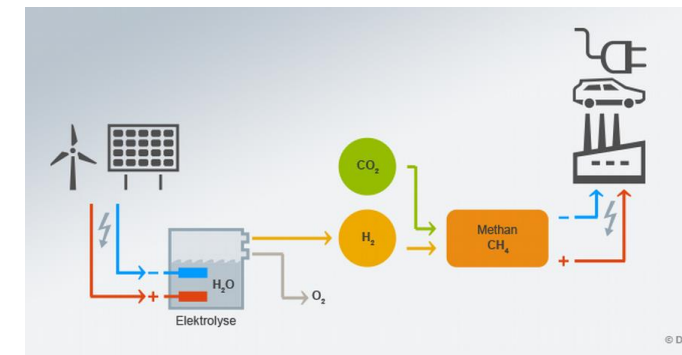
Power to Gas to Power → asymmetrisch  
Wirkungsgrad: ~28%

$\eta$ : Hydro ~ 90%  
Interkonnectoren - passive  
Speicherung -

$\eta$ : PSKW ~ 80%

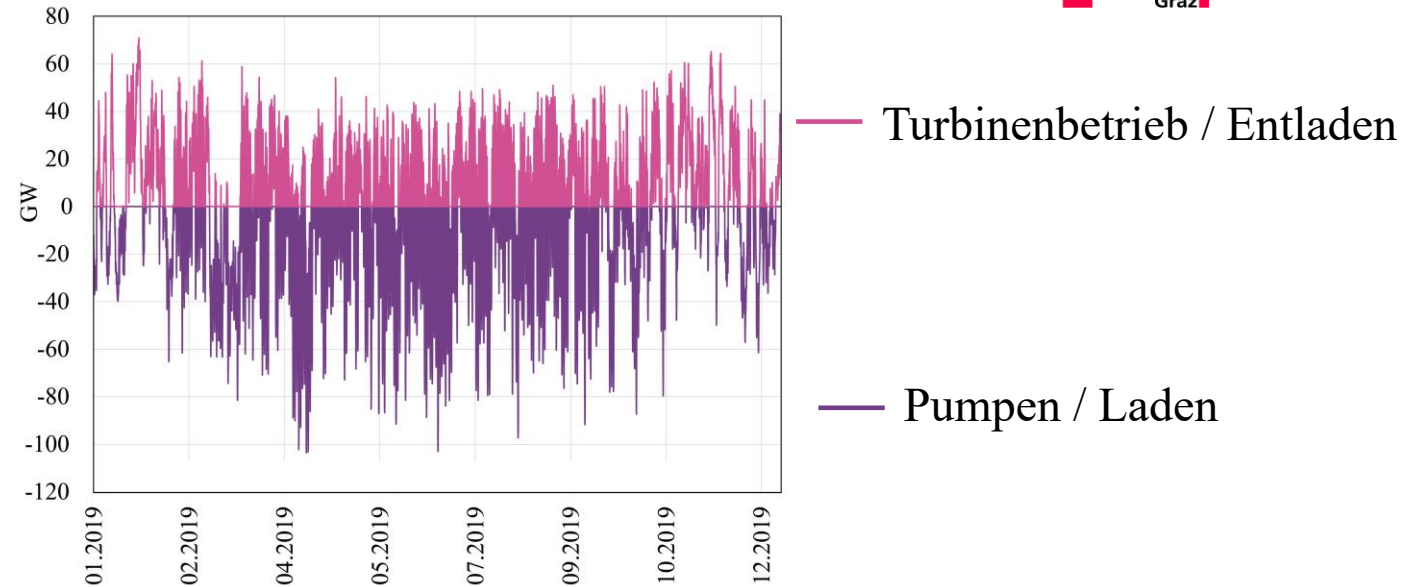


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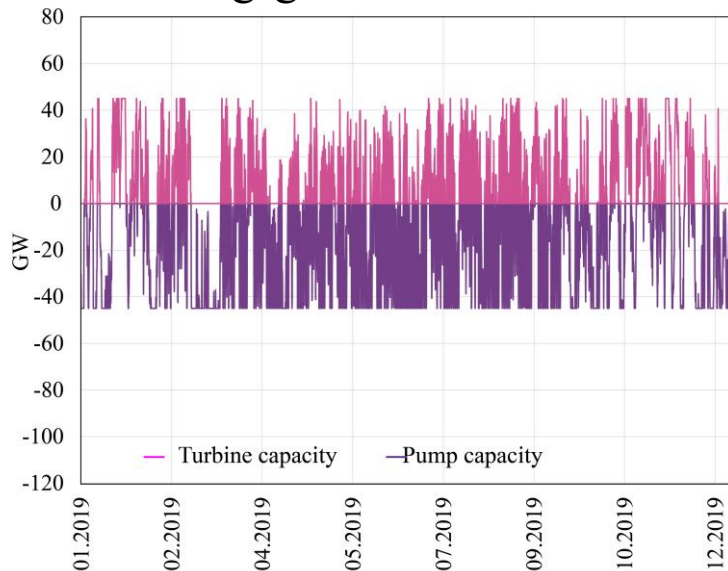


# Bedarf - Leistung

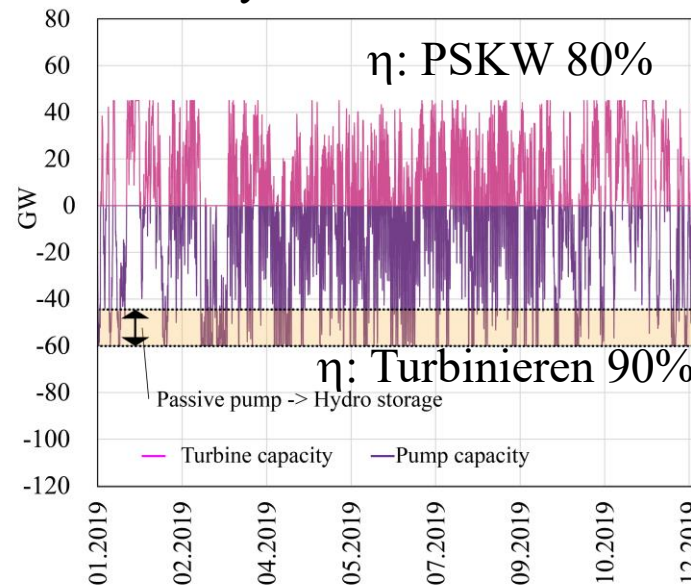
Ideal →  
asymmetrisch



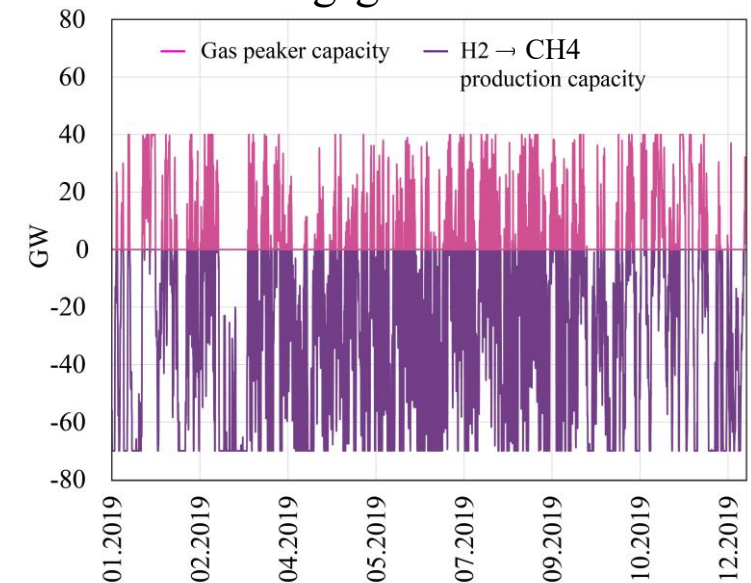
Pumpspeicher → symmetrisch  
Wirkungsgrad: 80%



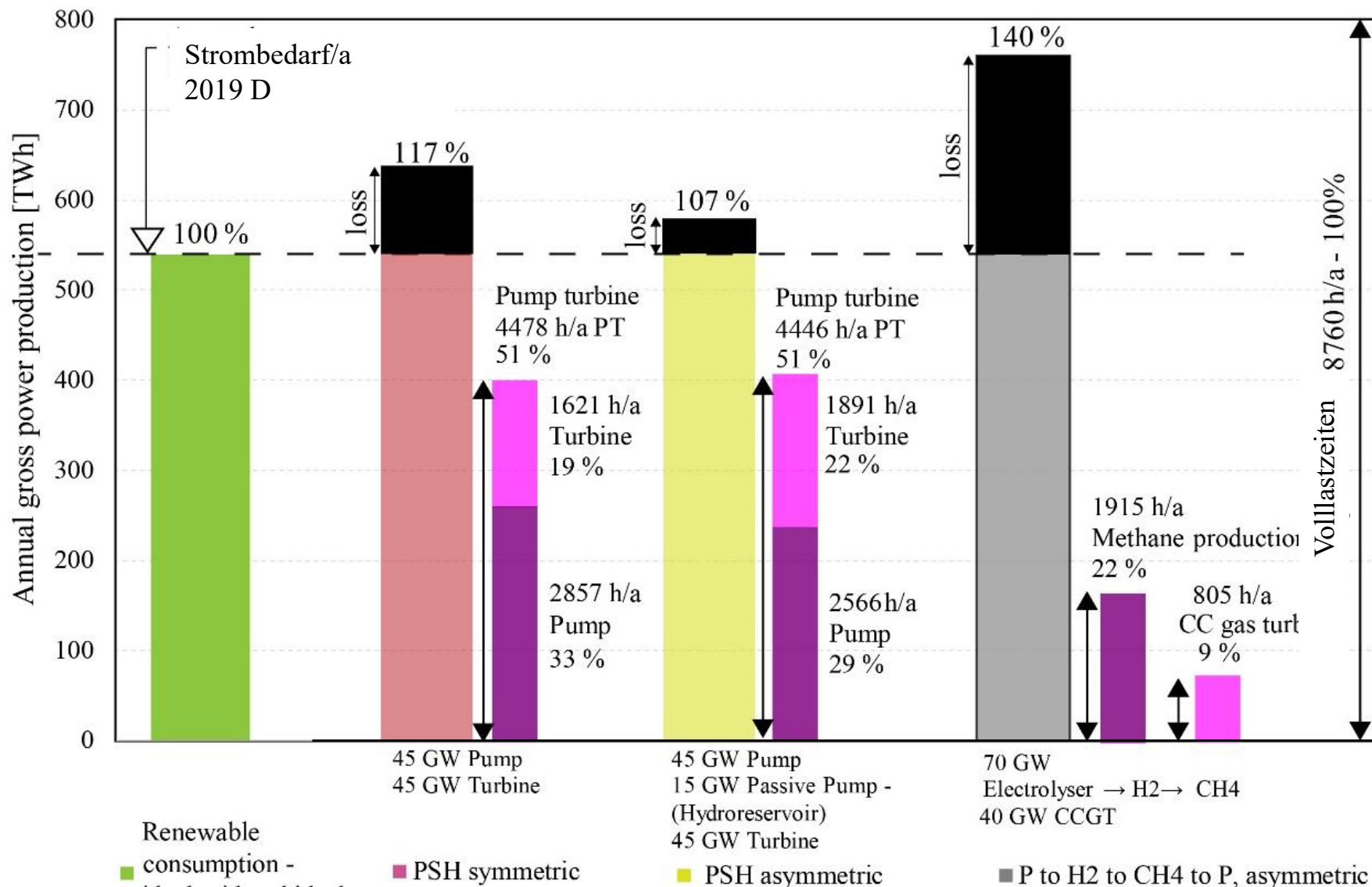
Pumpspeicher + Wasserspeicher → asymmetrisch

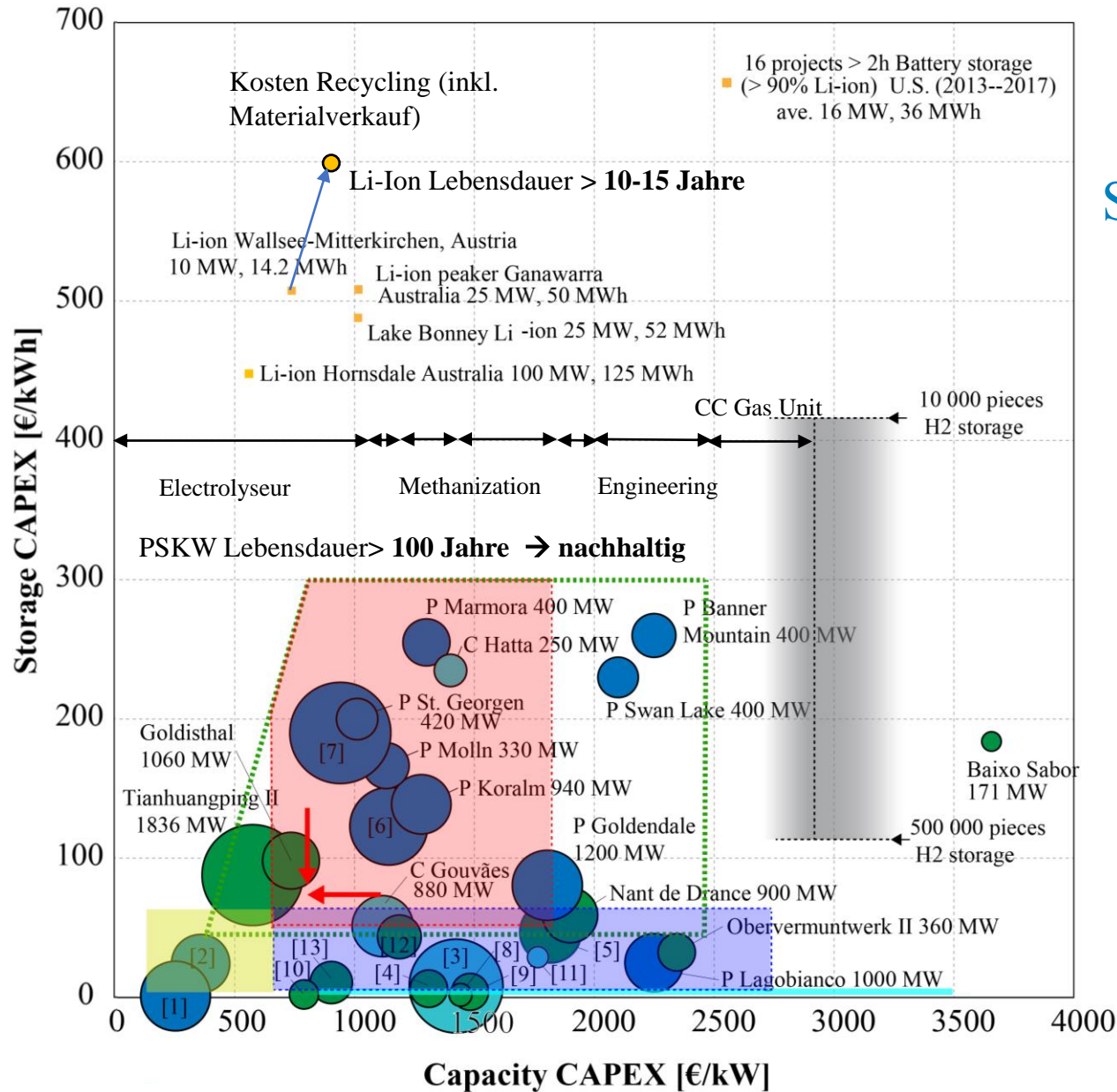


Power to Gas → asymmetrisch  
Wirkungsgrad: 28%



# 100 % Erneuerbarer Strom– Speicher Vergleich





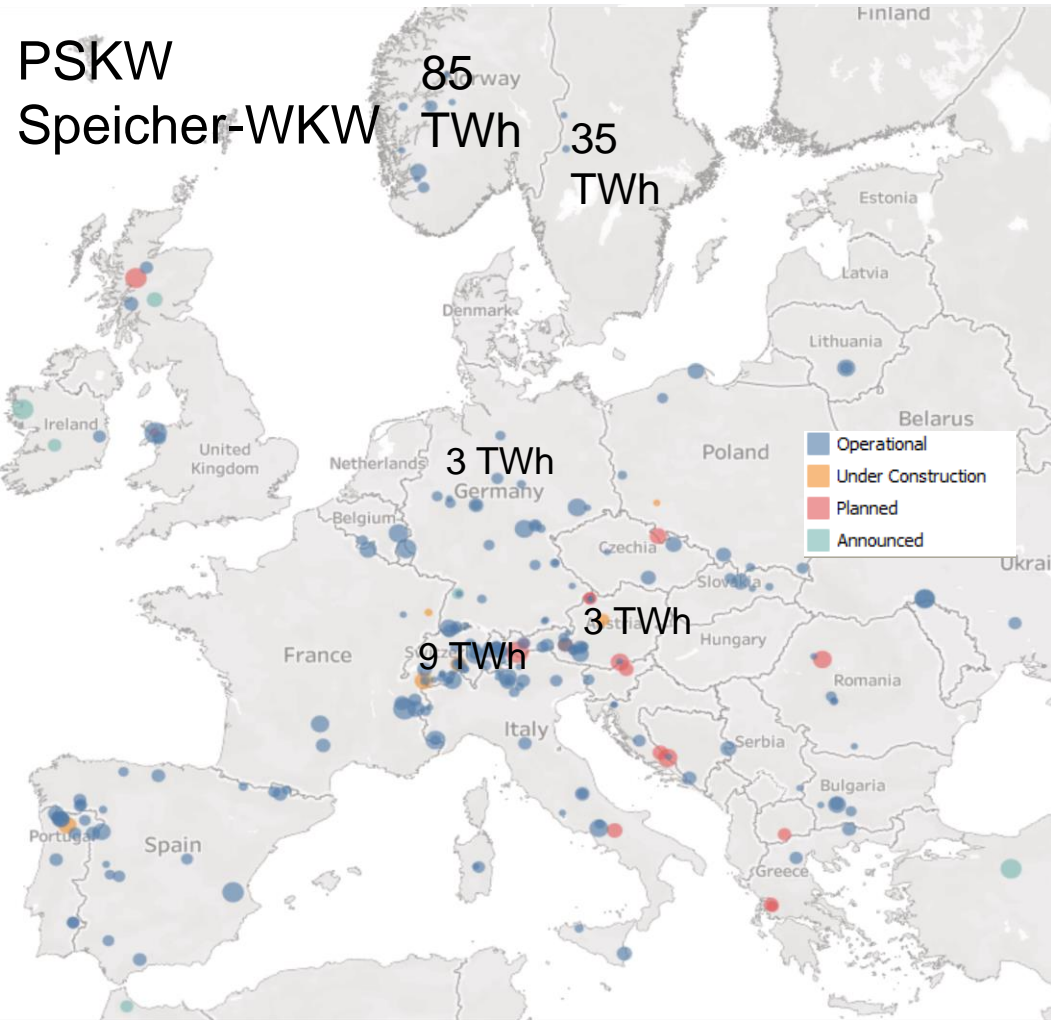
## Spezifische Invest. Kosten € / Leistung kW

## 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
- 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
- UPSH specific cost reduction by increase of storage volume resp. larger energy content and increased head
- [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 Erzeugung & Speicherausgleich

PSKW  
Speicher-WKW



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



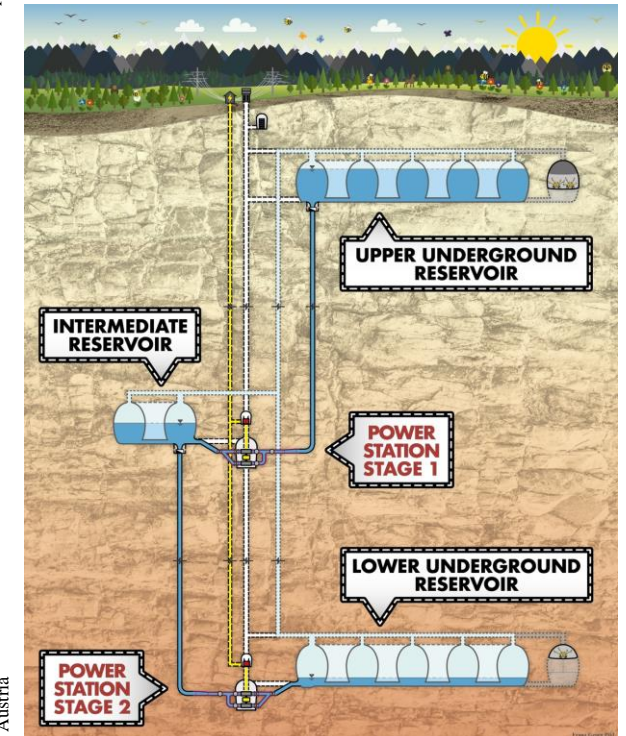
Source: <https://www.skagerakkraft.no>

## Speicherwasserkraft & Pumpspeicher



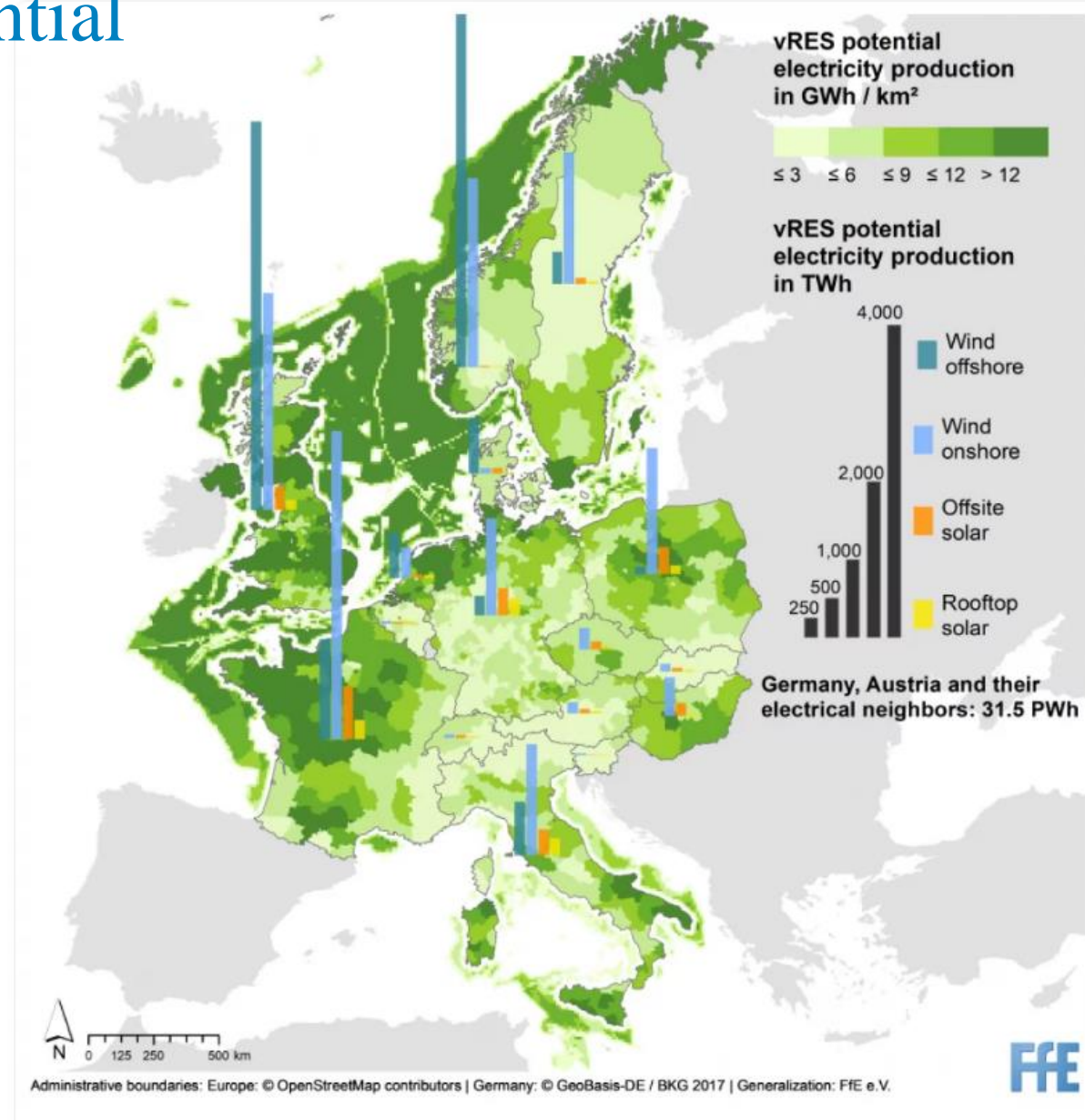
© Pökl F.G., ATCOLD 2018 Pumped Storage Hydropower in Austria

## Untertage - PSKW



© Franz Georg Pökl

# Erneuerbares Potential in Europa



**31500 TWh**  
Wind und Solar Potential

# 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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	Referenzen
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