Underground Energy Storage

A European Research Perspective

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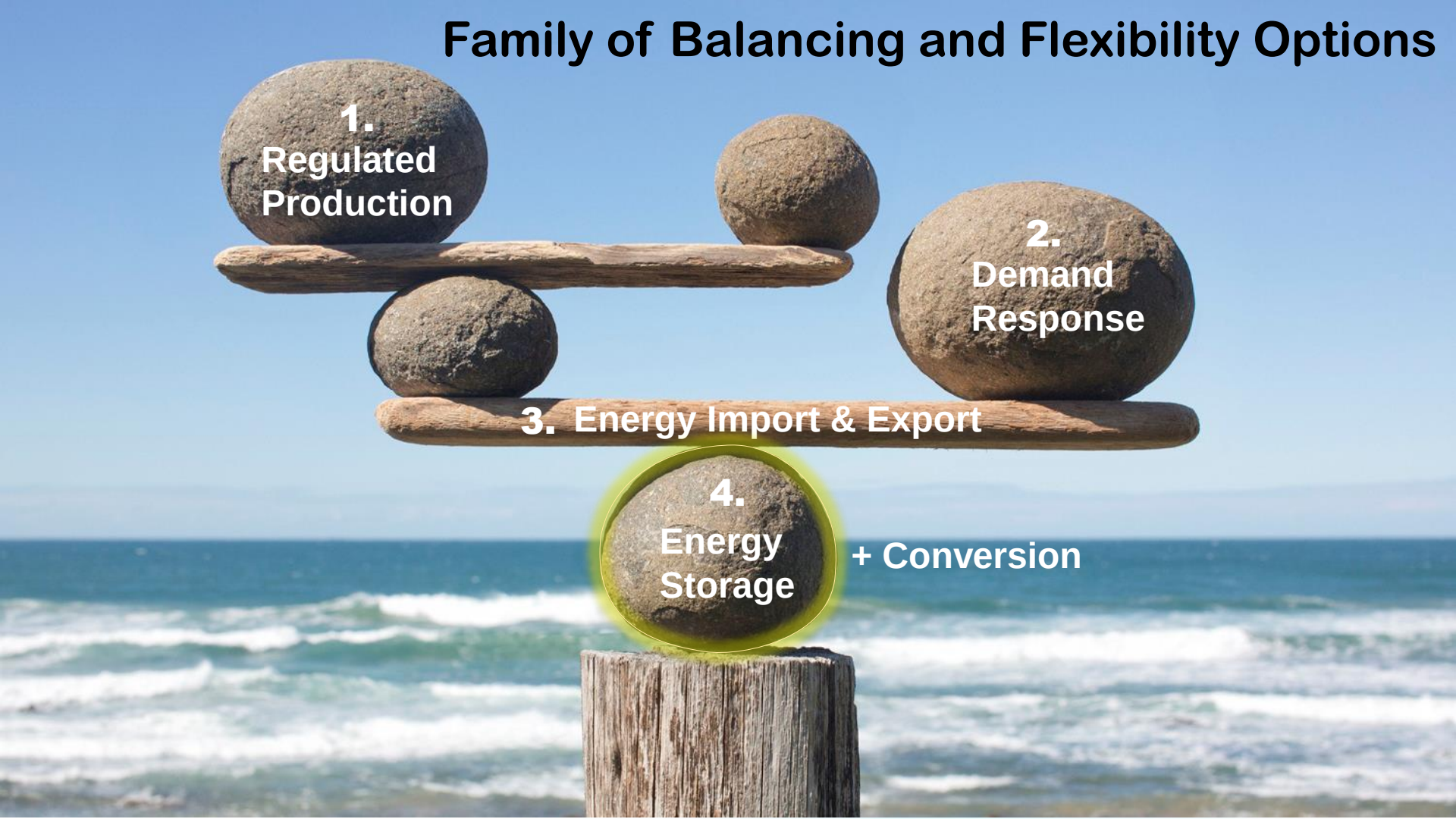
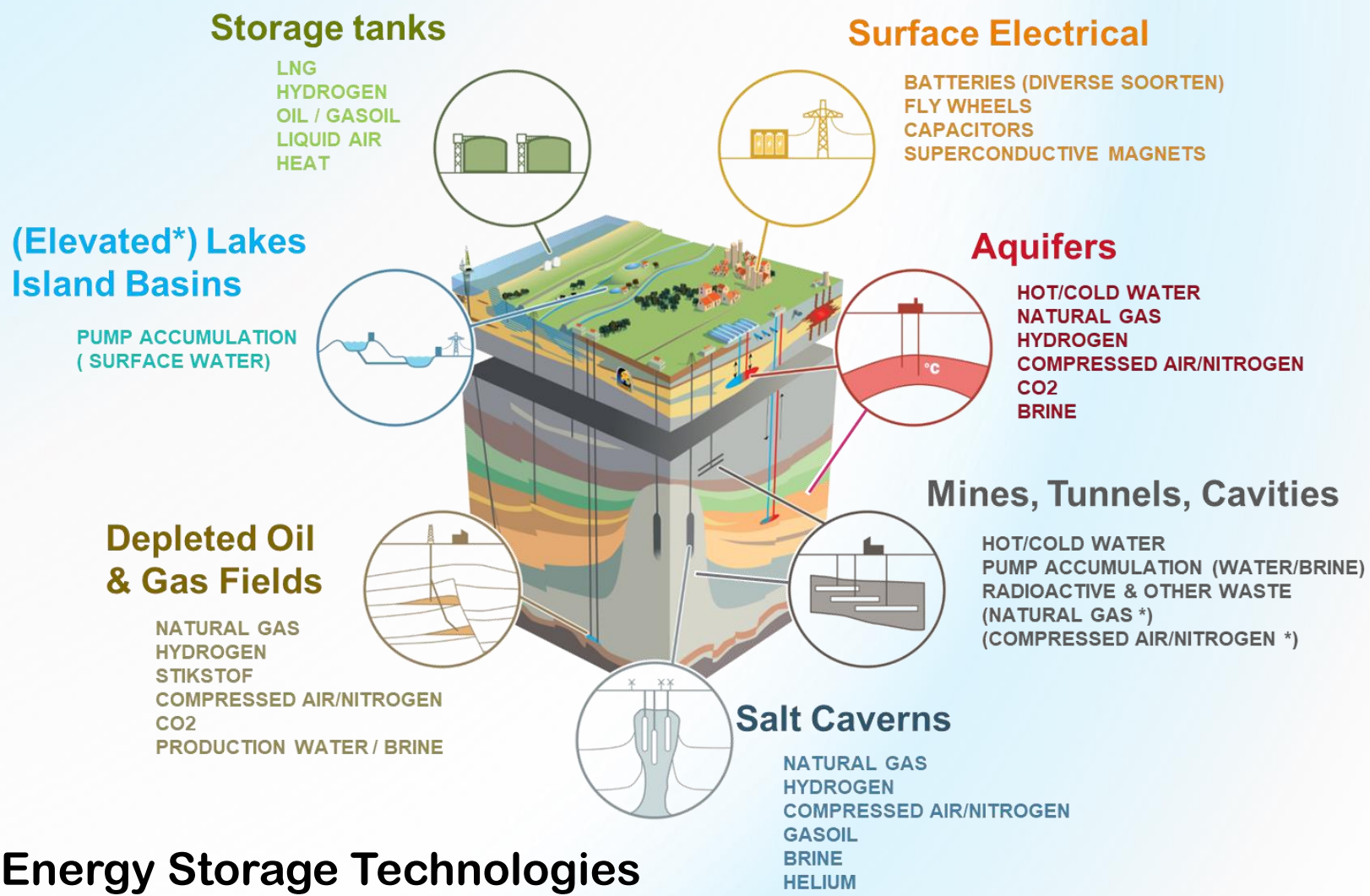
EuroGeoSurveys
European Geoscience for Society
The Geological Surveys of Europe

ECN › TNO innovation for life

Large-scale energy storage supports Europe’s ambitions for clean, secure and affordable energy

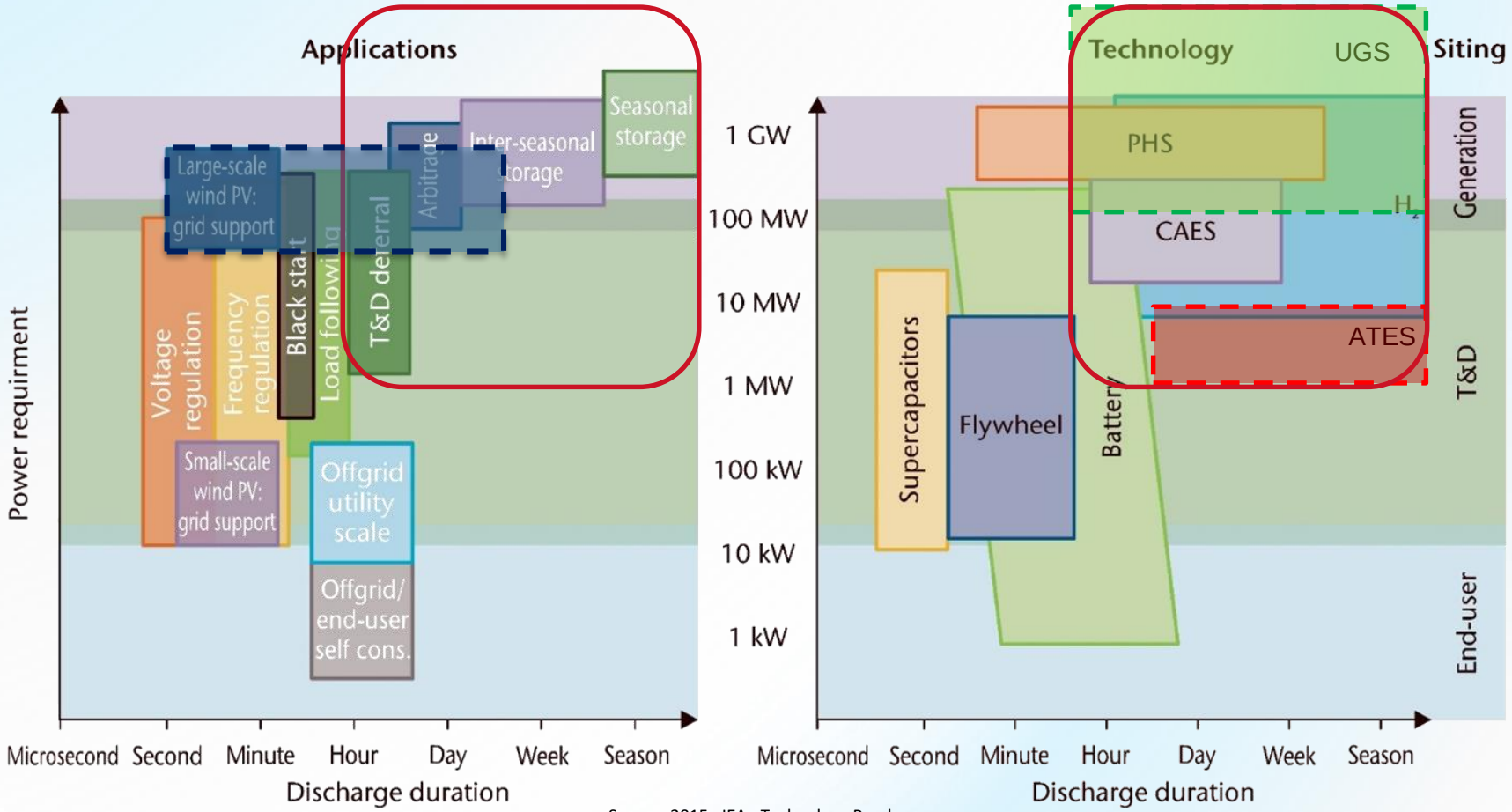
Family of Balancing and Flexibility Options





Family of Energy Storage Technologies

Family of Energy System Services

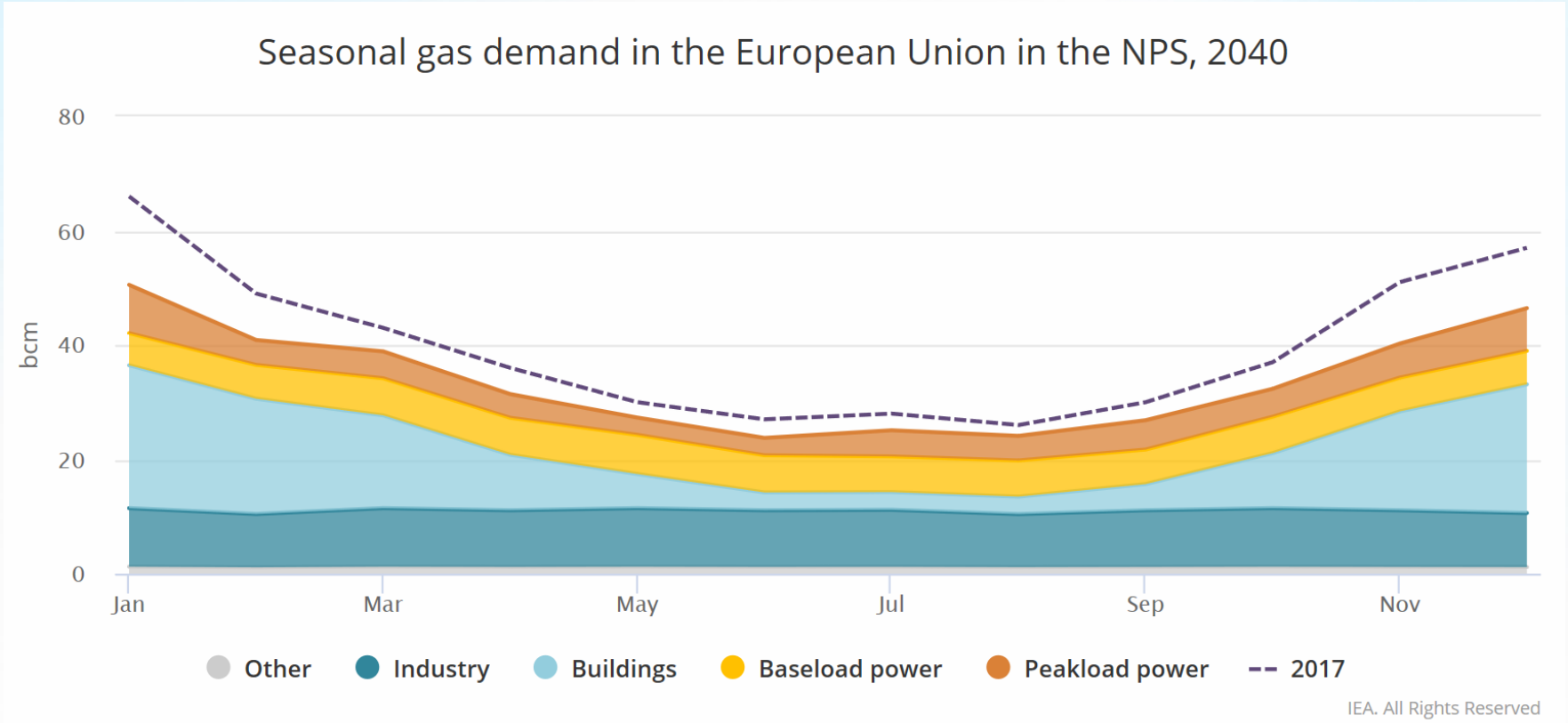


Source: 2015 - IEA - Technology Roadmap

Europe’s future energy demand continues to follow a seasonal pattern (heat) with superimposed demand peaks

Seasonal fluctuation gas demand (heating)

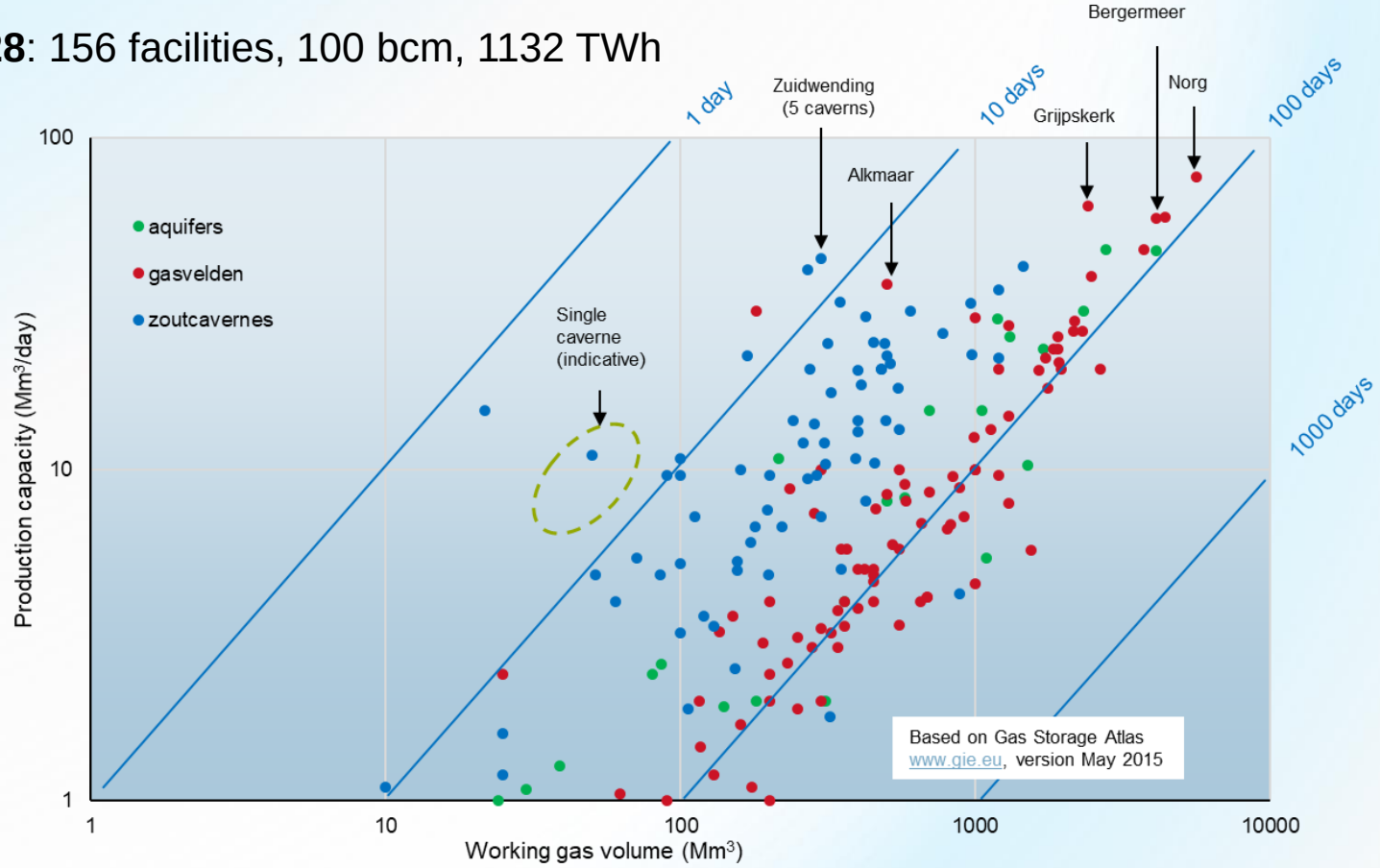
(EIA 2019)



European Underground Gas Storages

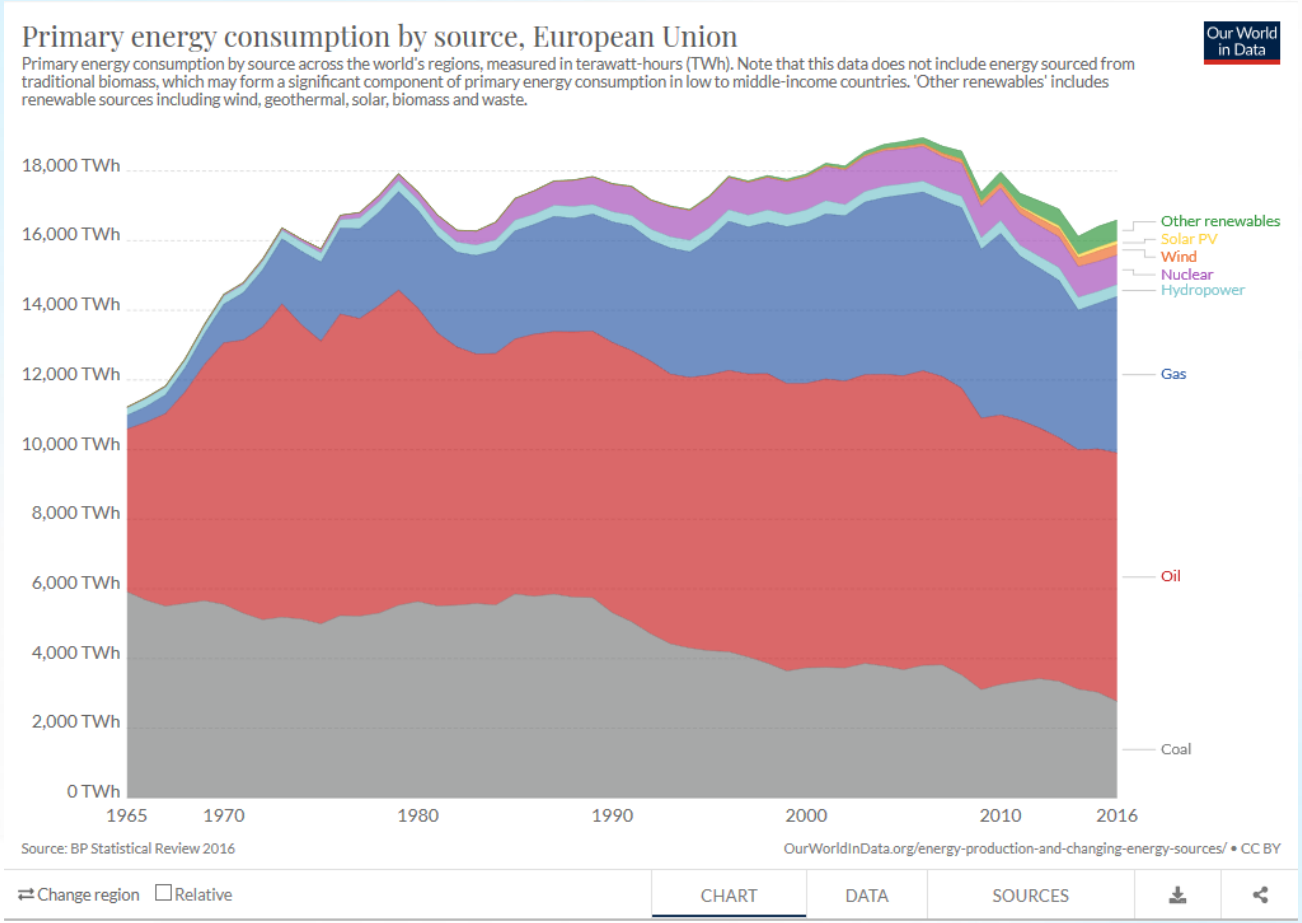
(GIE, 2015)

2018 EU-28: 156 facilities, 100 bcm, 1132 TWh



Share of UGS Capacity vs Primary Energy Consumption

(downloaded from ourworldindata.org, 2019, GIE-2019)



EU gas storage volume

ca. 1132 TWh

156 operational sites

EU primary energy consumption 2016

ca. 16.400 TWh

storage factor ~ 7%

EU primary gas consumption 2016

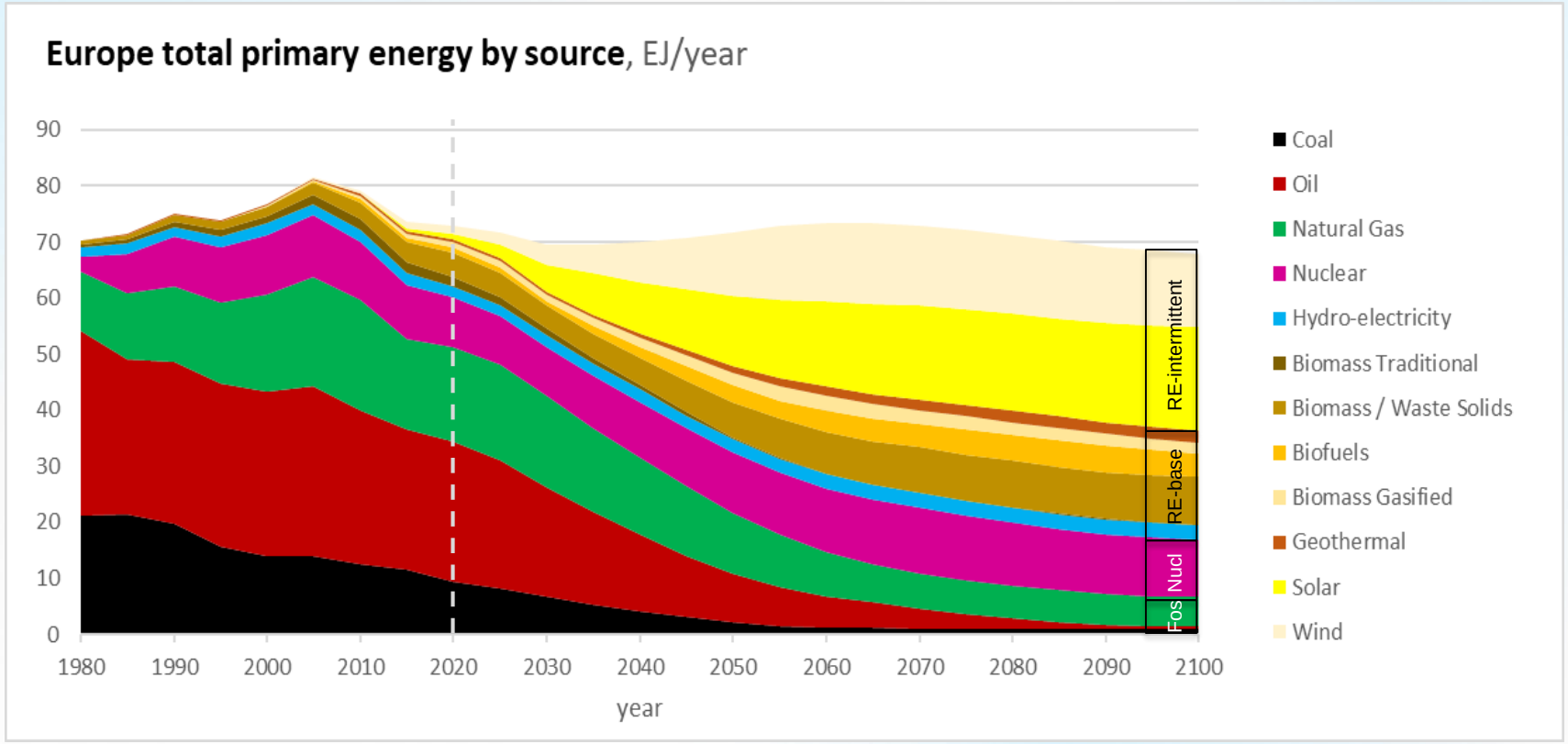
ca. 4.200 TWh

storage factor ~ 27%

High shares of intermittent renewables will require flexibility beyond the capacity of surface electrical storage options

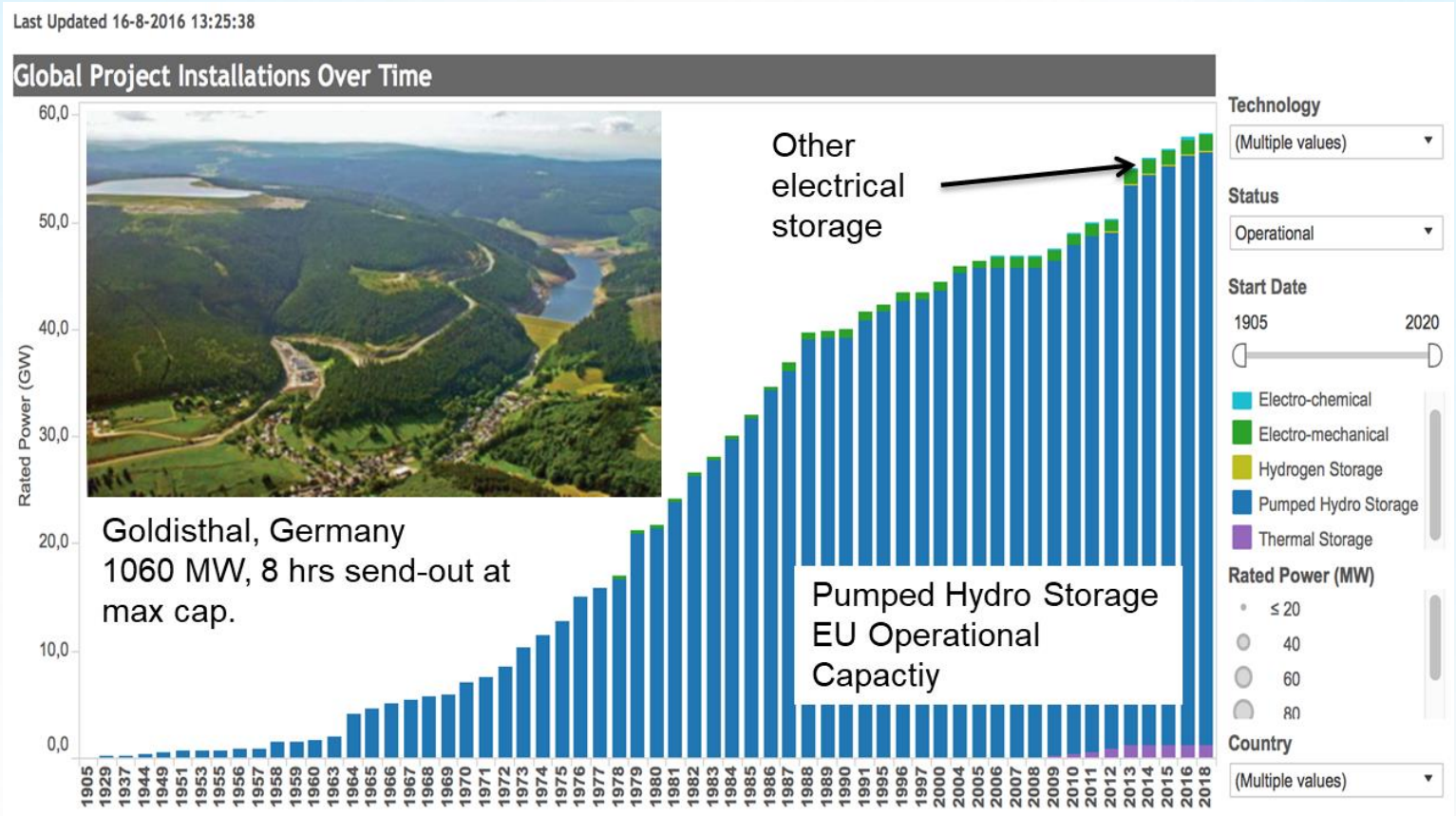
Strong increase of intermittent RE (EU and Globally)

(Shell Sky Scenario, 2019)



Pumped Hydro Storage

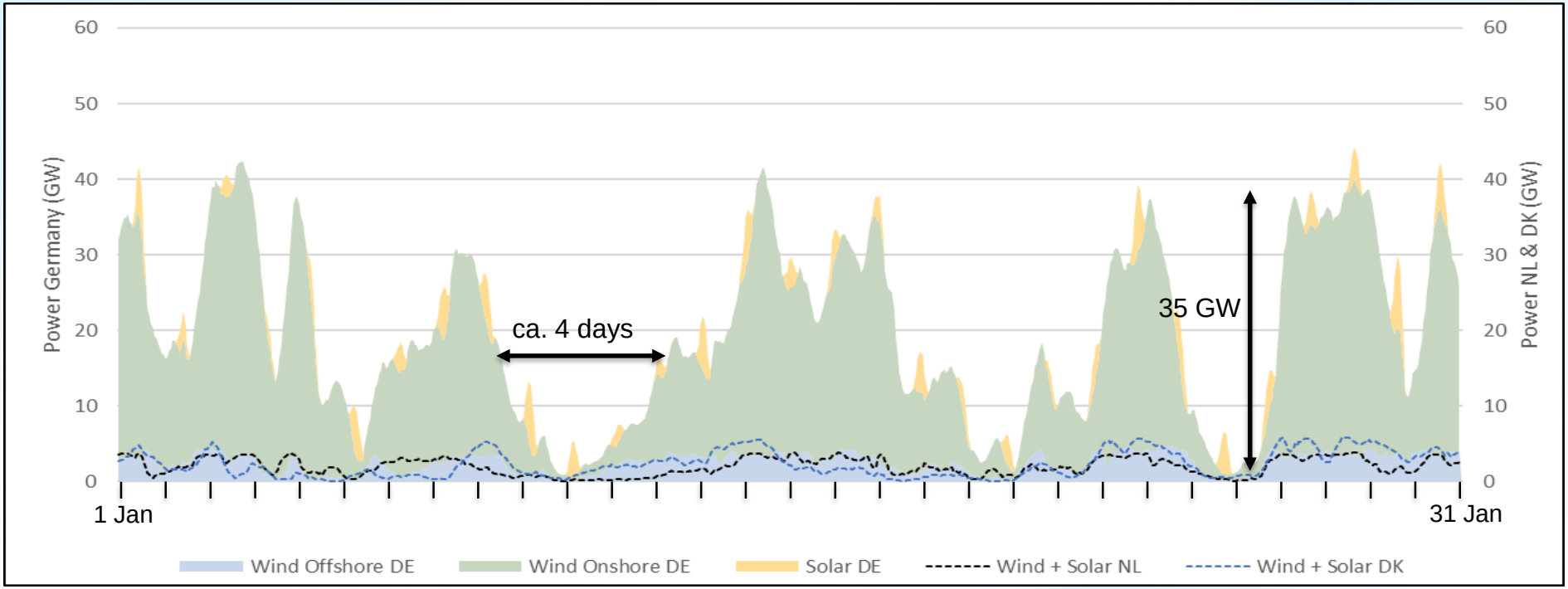
(DOE Global Energy Storage Database)



Total PHS EU: ~ 0,5 – 1,0 TWh assuming 8 - 16 hrs average duration (0,1% of current UGS capacity)

Wind and Solar production, DE-NL-DK, January 2018

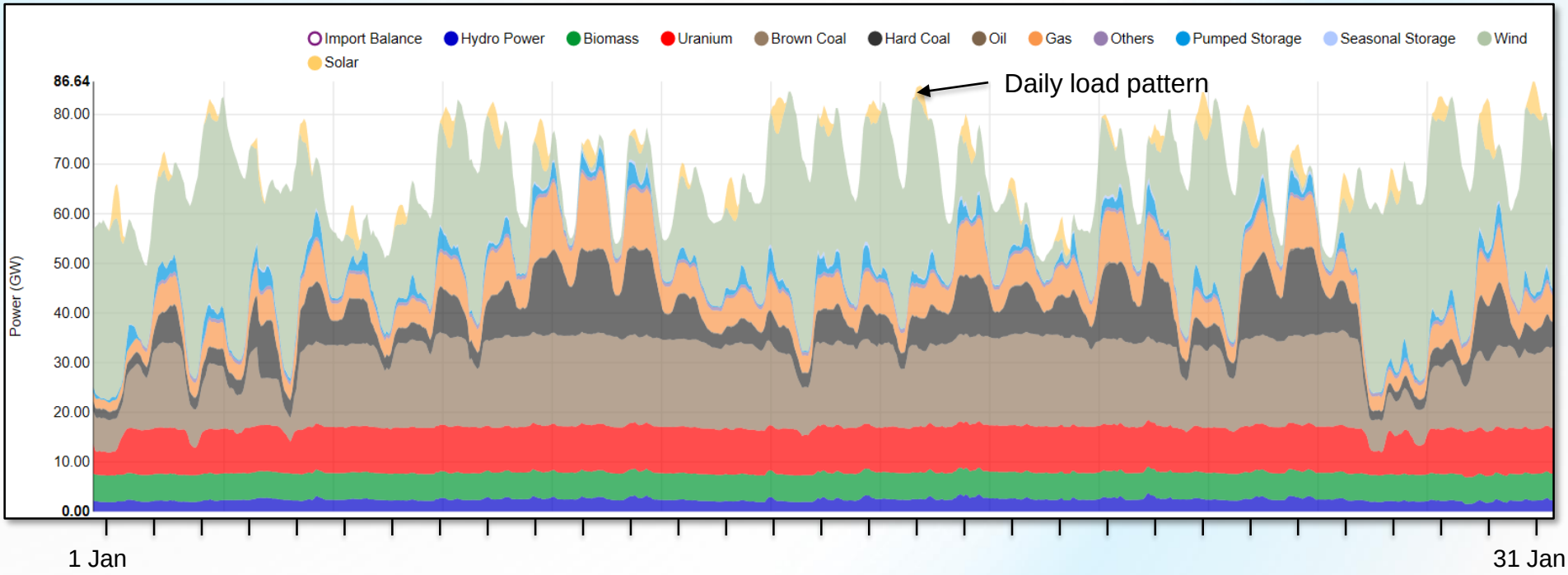
(Energy-charts.de, Frauenhofer 2019, ENTSOE, www.energidataservice.dk)



Germany: ca. 60 GW installed capacity (comparable to Dutch renewable ambitions in 2050)
ca. 30.000 wind turbines

Electricity production Germany, January 2018

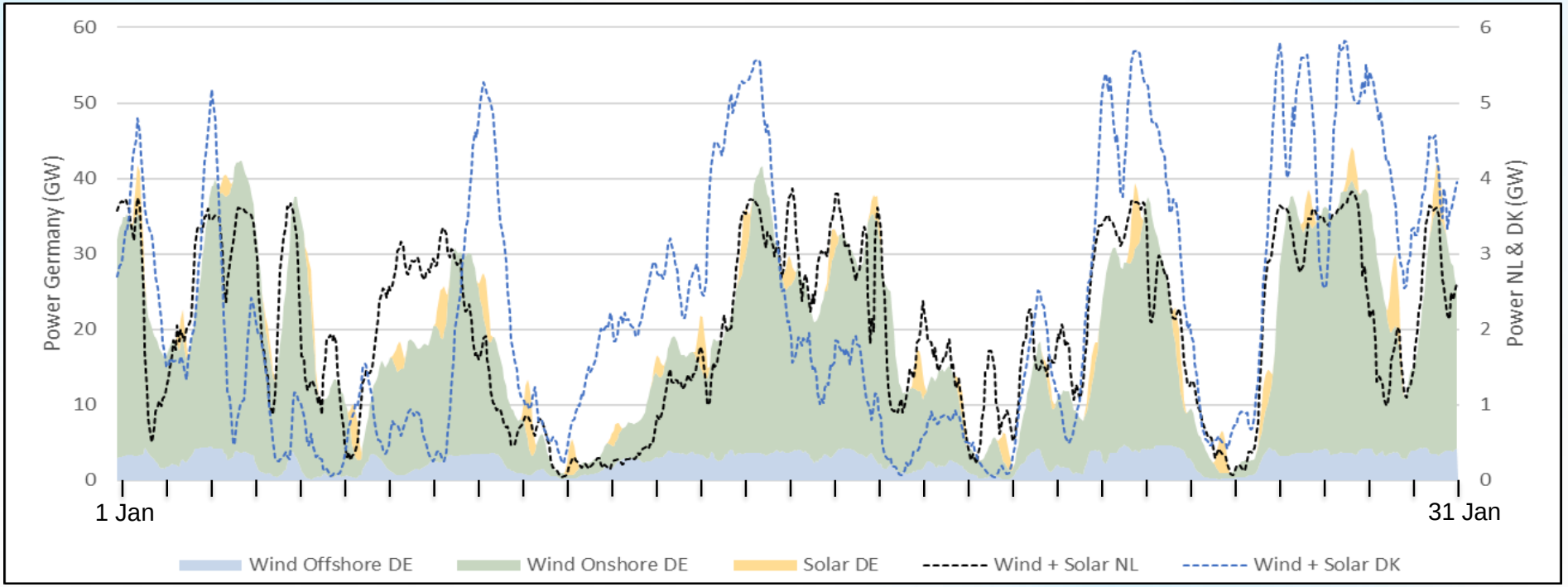
(Energy-charts.de , Frauenhofer, 2019)



Coal, Lignite and Natural gas mainly used as balancing capacity.

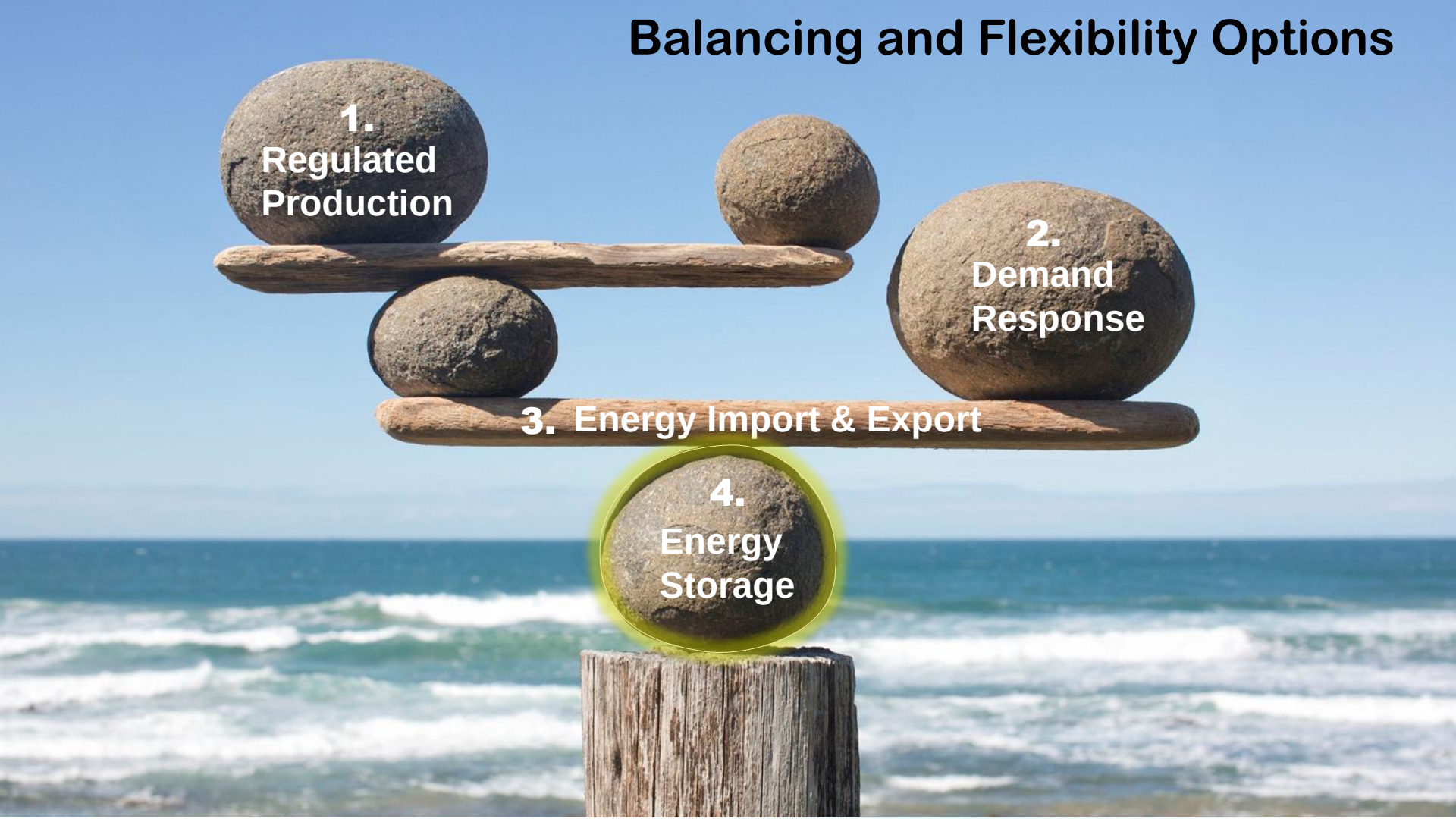
Wind and Solar production, DE-NL-DK, January 2018

(Energy-charts.de, Frauenhofer 2019, ENTSOE, www.energidataservice.dk)



Similarity of wind patterns (NL and DK scaled to German wind capacity)

Balancing and Flexibility Options



Battery Storage

Jardelund (Northern Germany)
ca. 50 MW, duration 1 hour = 50 MWh

Tesla Australia: ca 129 MWh

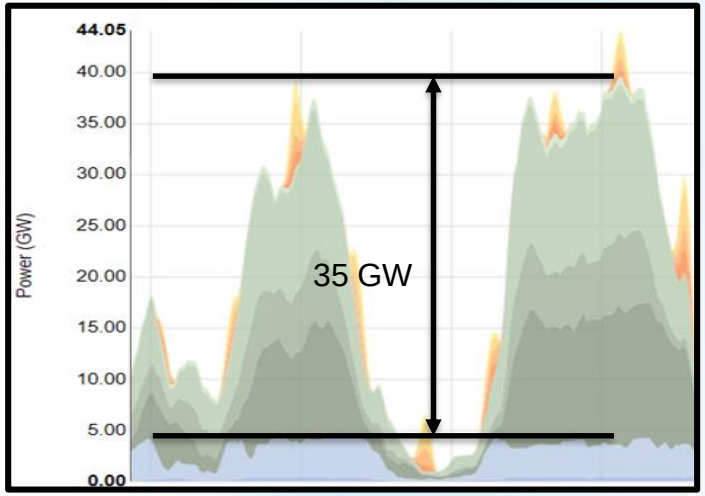
news.enecogroup.com

Replace one day of wind

35 GW x 24 hours = 860 GWh

Largest battery (Australia)
ca. 100 MWh

$$\frac{860.000\ \text{MWh}}{100\ \text{MWh}} = 8.600\ \text{batteries}$$



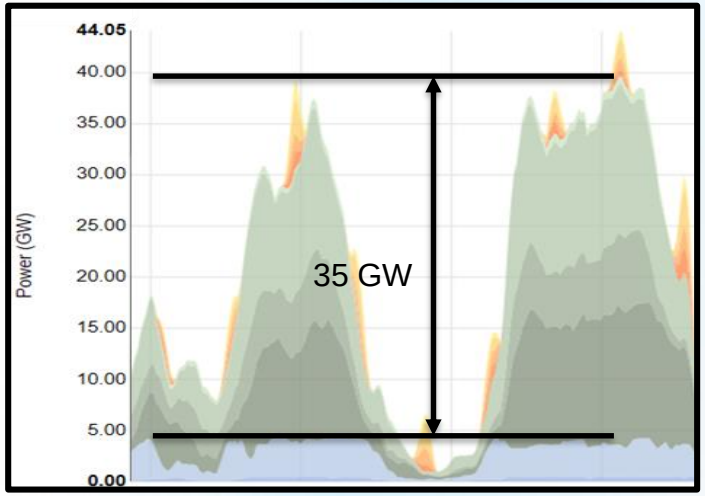
Natural batteries: Pumped Hydro Lakes

Replace one day of wind

35 GW x 24 hours = 860 GWh

Goldisthal = 8.480 MWh

$$\frac{860.000\ \text{MWh}}{8.480\ \text{MWh}} = \text{ca. 100 Lakes}$$



Underground storage technologies deliver clean and economically viable flexibility options for resilient and zero emission energy systems

Underground Energy Storage

Green gas	**ca. 0.5**	**–**	**50 TWh, seasonal/peak**
Hydrogen	**ca. 0.1**	**–**	**10 TWh, seasonal/peak**
Compressed Air	**ca.**	**1 –**	**3 GWh, peak**
Underground PHS	**ca.**	**1 –**	**3 GWh, peak**
ATES	**ca.**	**1 –**	**50 GWh, (inter) seasonal**

Subsurface energy storage technologies contribute to clean, affordable and secure energy :

- Based on (net-)zero emission carriers (heat, electricity, renewable gases)
- Applies to large scale flexibility demand (seasonal + high shares of RE)
- Scalable capacities
- Proven technologies in salt caverns, aquifers and depleted gas fields
- Sectorial integration through conversion / Power-to-X
- (Re-)use of existing energy infrastructure and assets

Effective valorization and implementation of large-scale underground energy storage depends on:

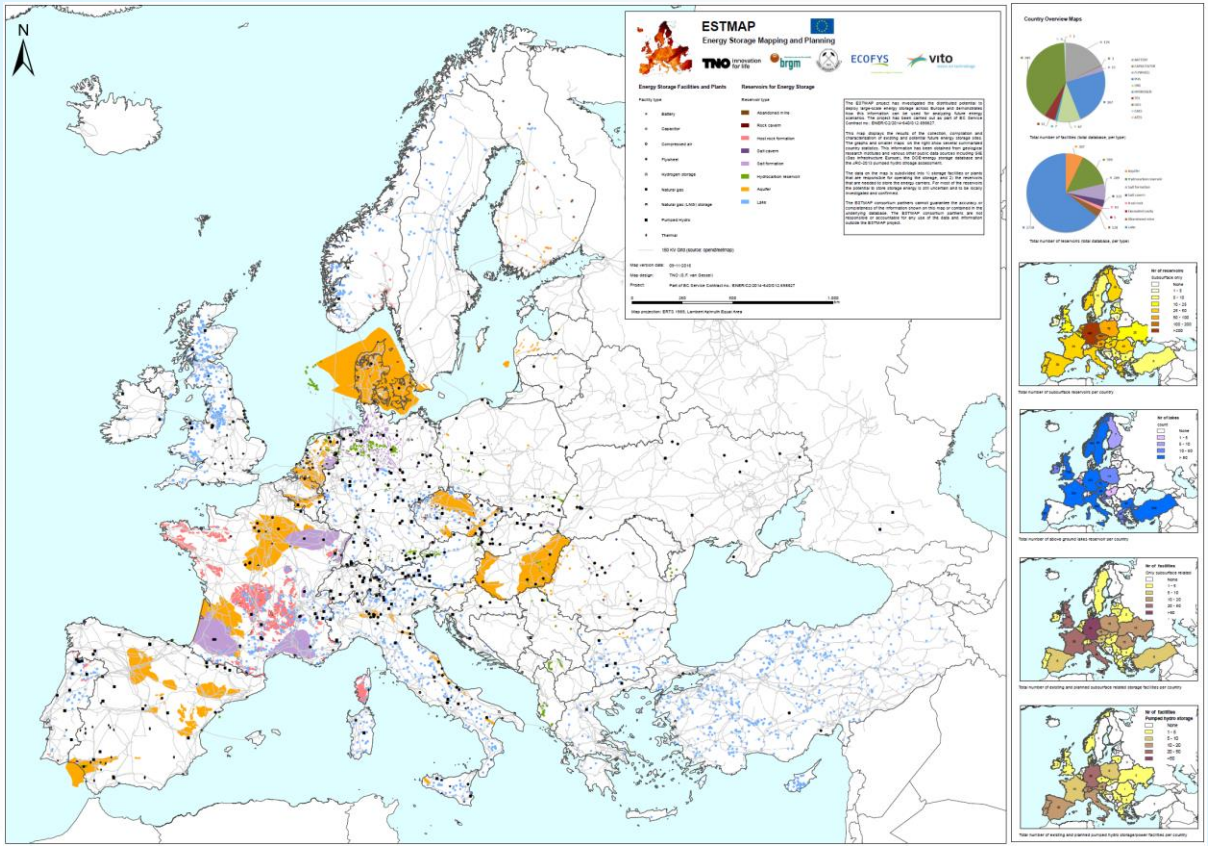
- Close cooperation within the Industry–Research–Policy nexus (innovation, pilots, system integration, social license to operate)

- Plug & Play datasets for energy systems modelling (demand/supply) and portfolio management

- Timely action (long lead times relative to climate and transition ambitions)

European Energy Storage Mapping and Planning

EC Service Contract no.: ENER/C2/2014-640/S12.698827 (www.estmap.eu)



ESTMAP

Energy Storage Mapping And Planning

www.estmap.eu

Mapping of Energy Storage Sites

Above ground / Subsurface

Existing and Future Potential

Standardized Technology KPI's

Application in EU systems models

High-level Research & Innovation challenges:

- Raise TRL of clean storage technologies (industry pilots, economy, efficiency)
- Assess future storage demand and system contributions (energy scenarios)
- Standardized KPI's and prospect evaluation methods (integration and correlation)
- Plug & Play information systems for modelling, portfolio management and planning
- Prepare Social License to Operate (risks, legal, societal awareness)

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Thank you for your attention





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