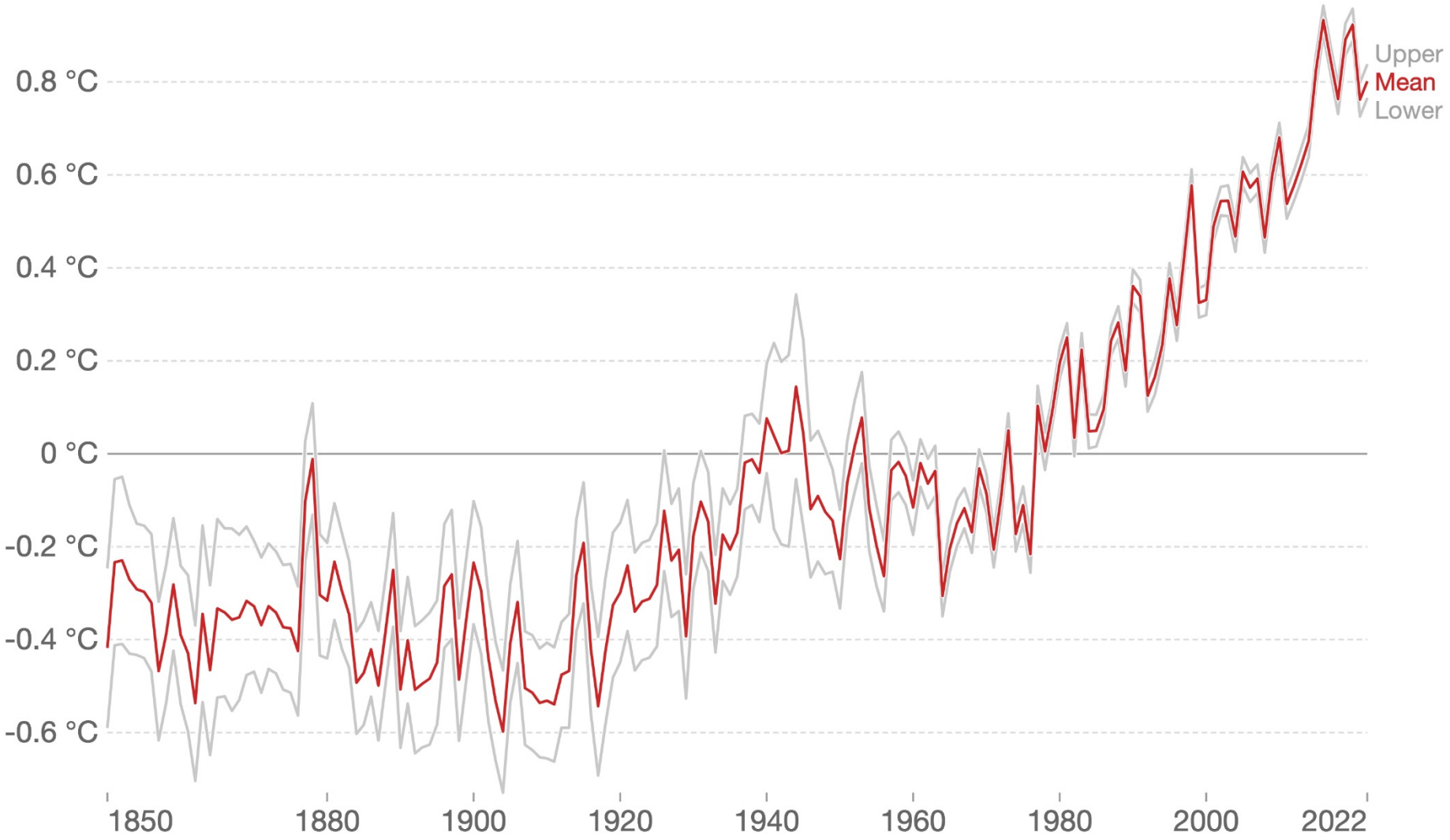
The Quest for Safe, Sustainable and Affordable Energy for the World

September 11, 2023

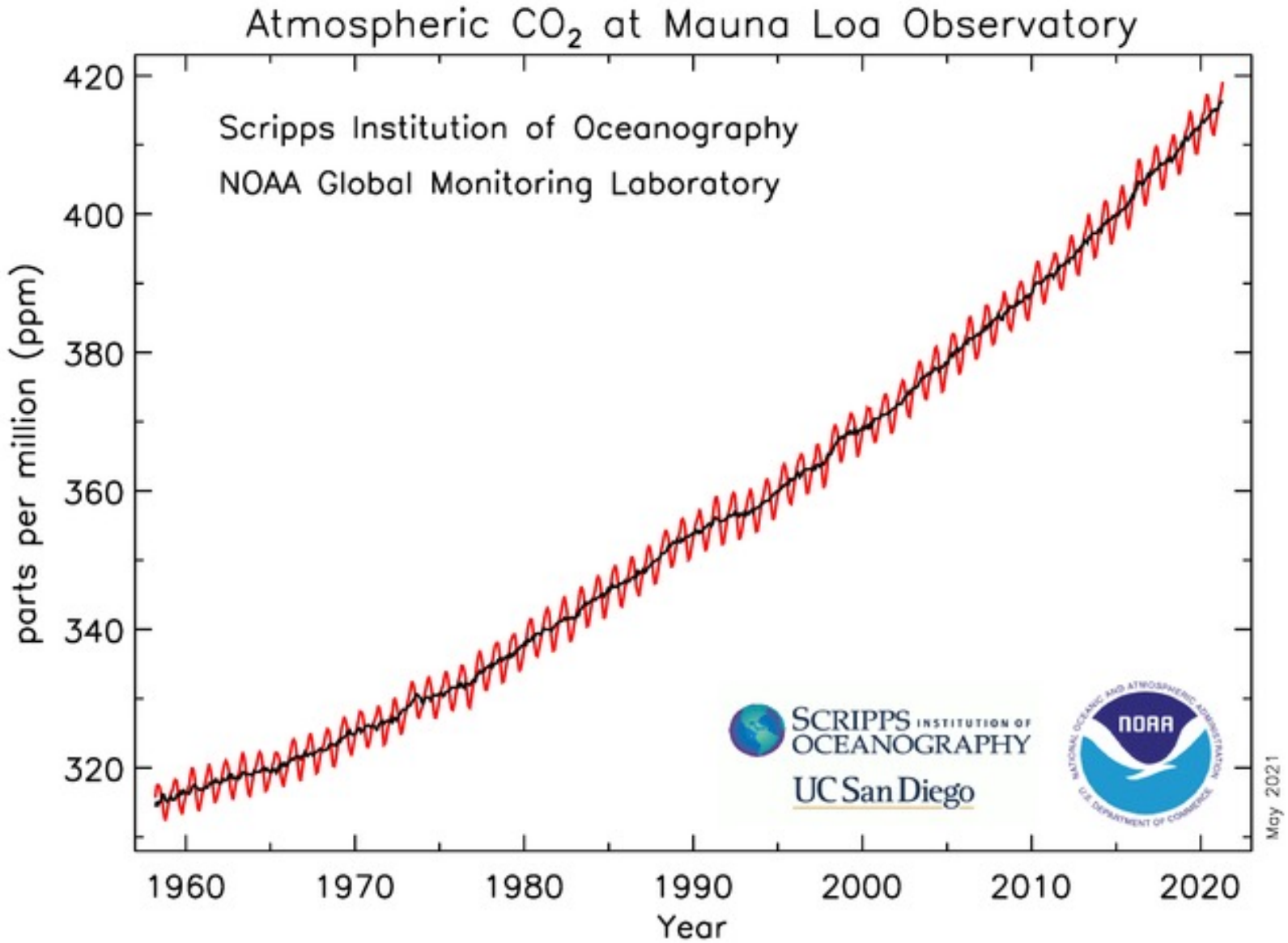
Lino Guzzella

Average Global Temperature Development

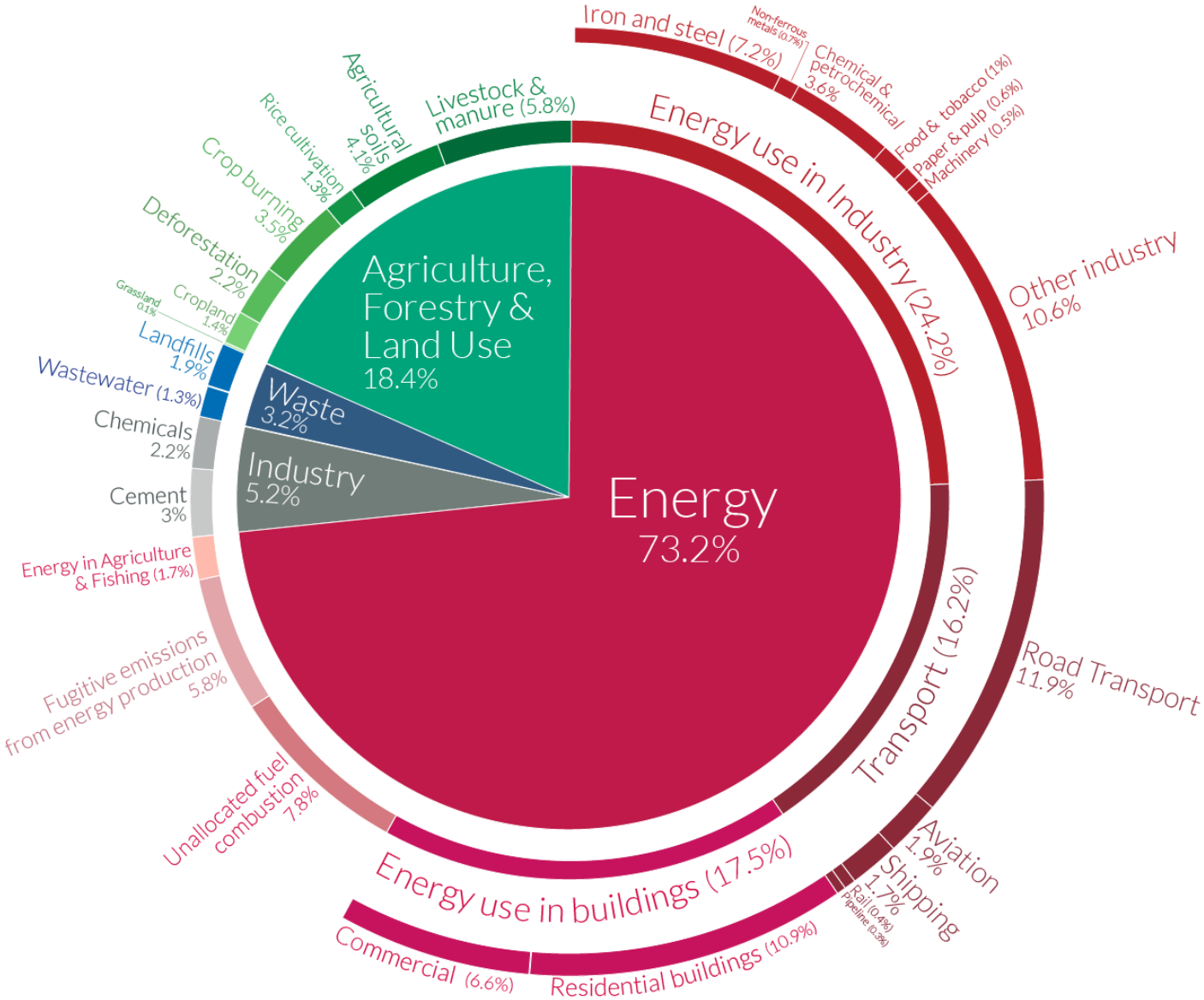


https://ourworldindata.org/co2-and-greenhouse-gas-emissions

Atmospheric CO_2 Concentration

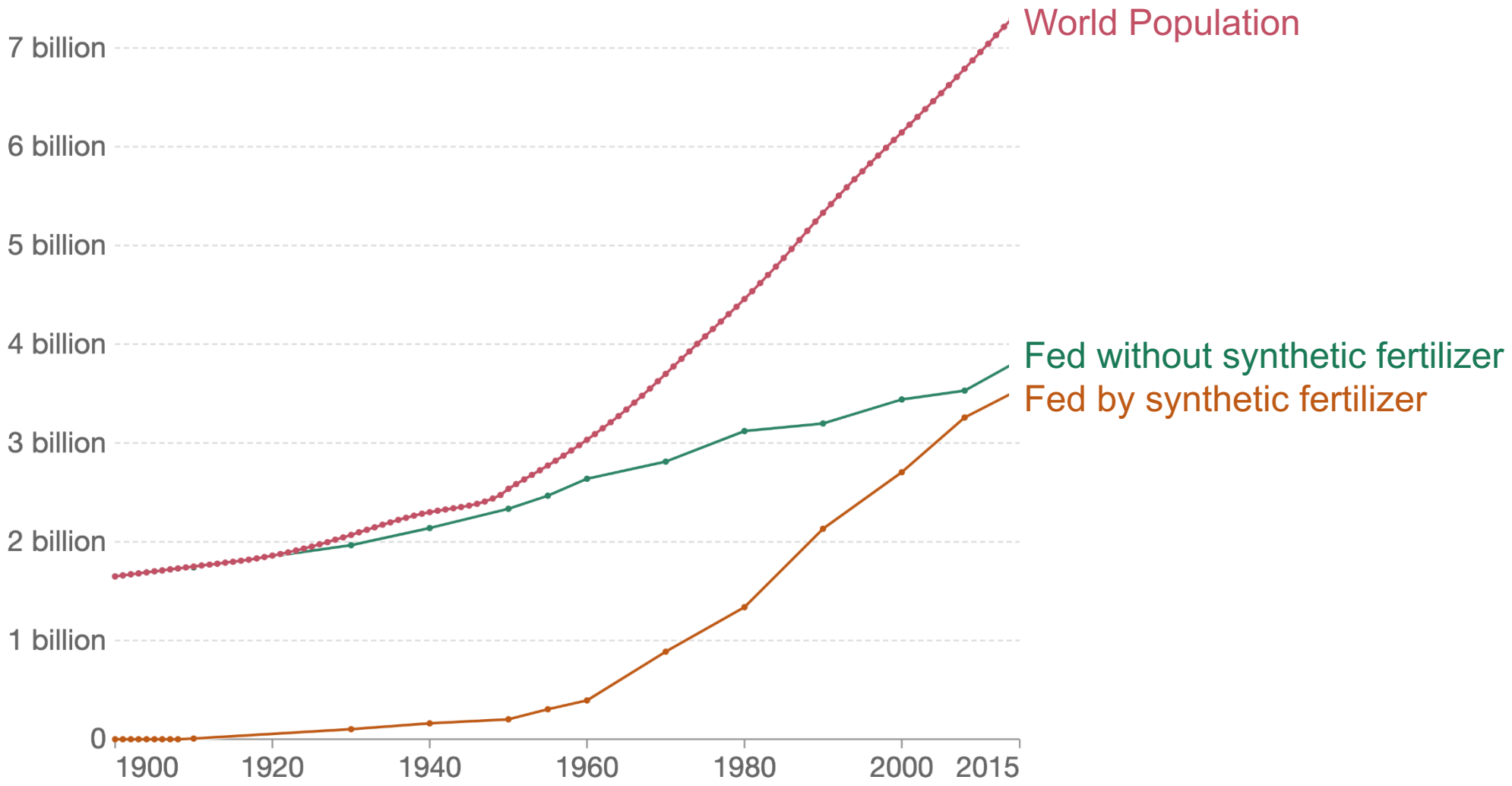


Global CO_2 Emission (2020)



https://ourworldindata.org/

What Feeds the World?



https://ourworldindata.org/

How to Produce Synthetic Fertilizer?

Nitrogen
(78% ambient air)

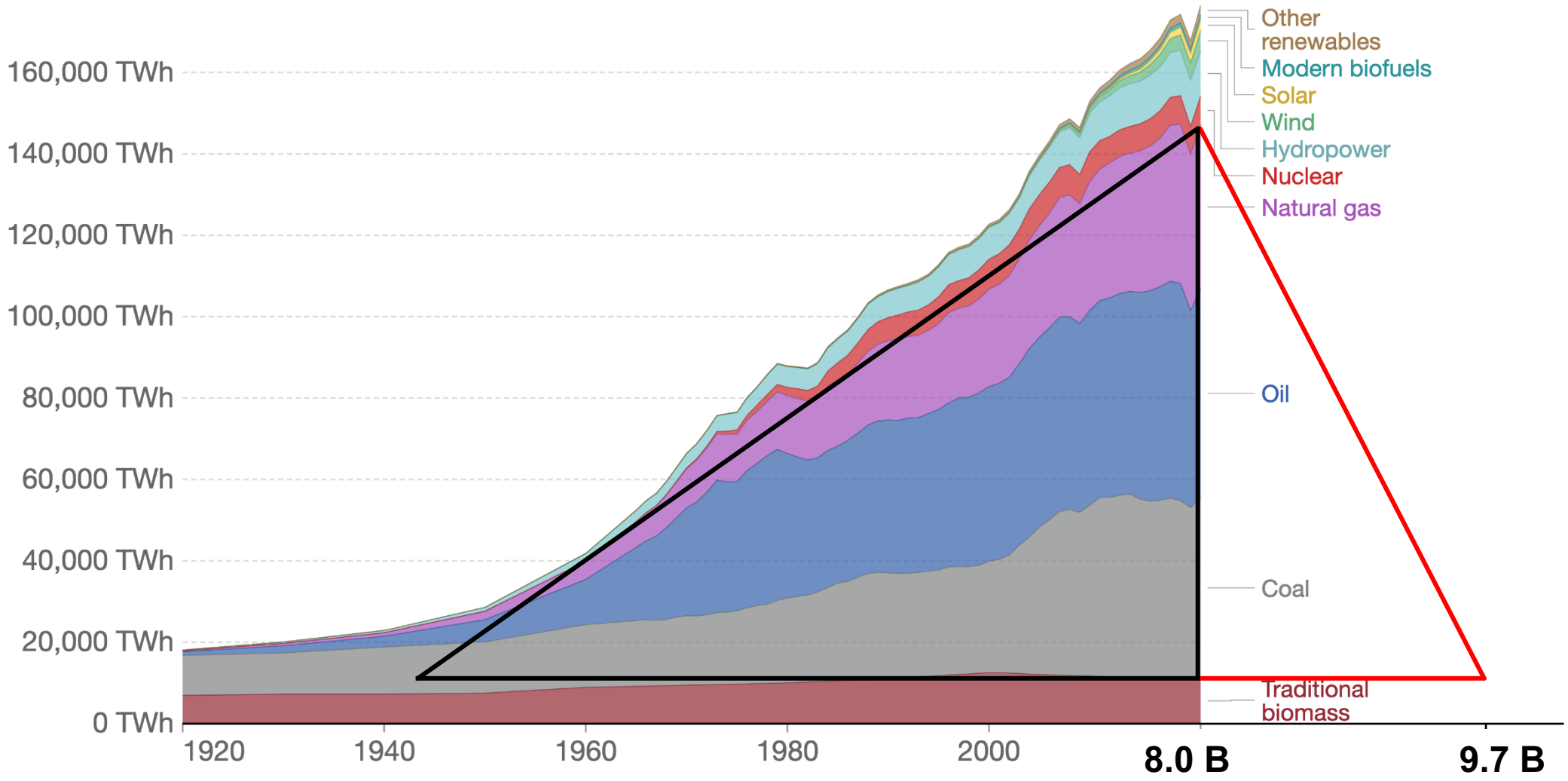
Natural
gas

The Nutrien Redwater Fertilizer plant near Fort Saskatchewan, Alberta, Canada, October 7, 2021.

Ammoniumnitrate
Urea
……

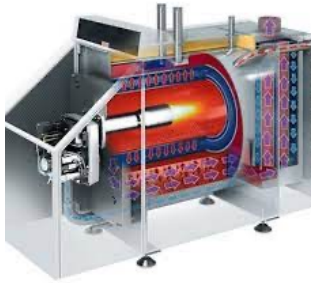
Total ca. 230 Mio. t per year, ca. 30 % China, ca. 10% Russia, …

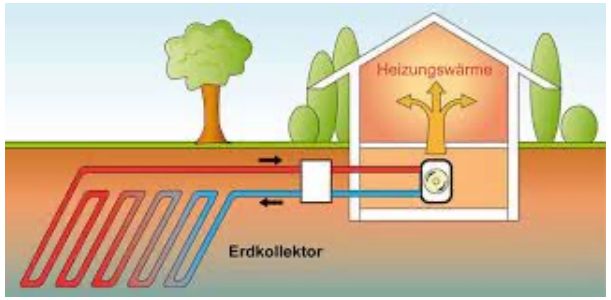
Global Primary Energy Consumption



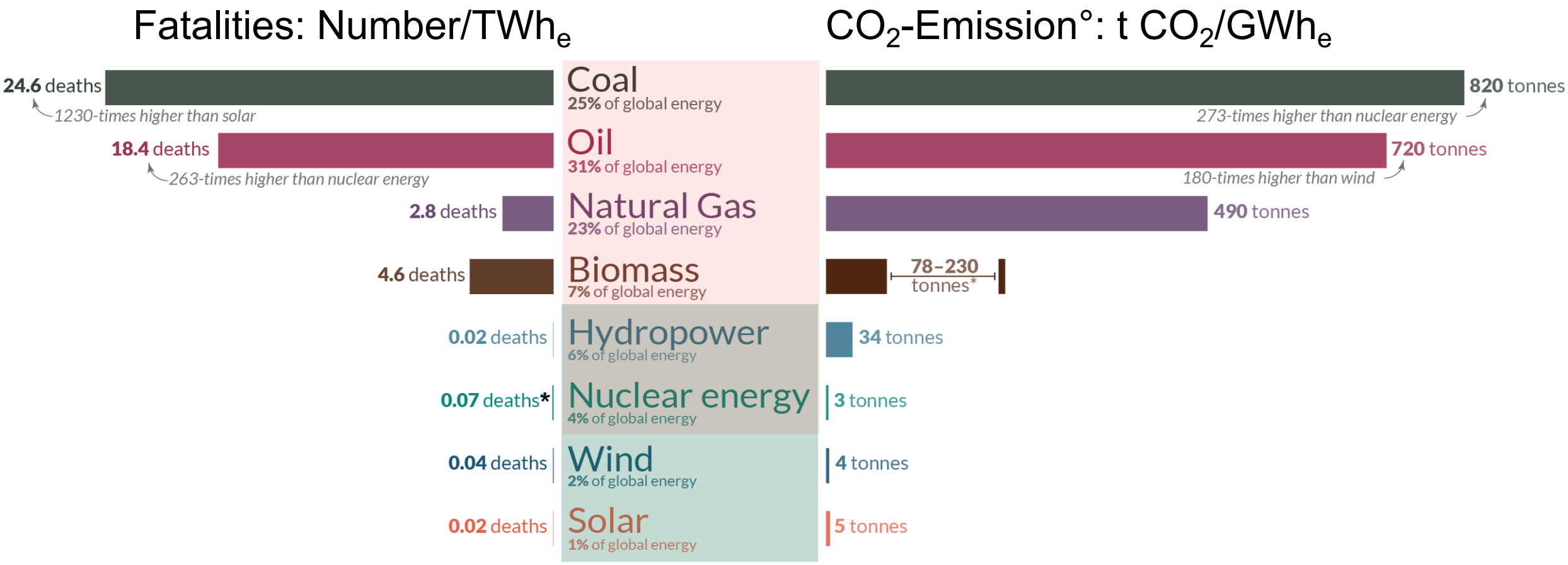
https://ourworldindata.org/

Key Element – Electrify Everything …





Comparison of Electricity Generation Systems



https://ourworldindata.org/,

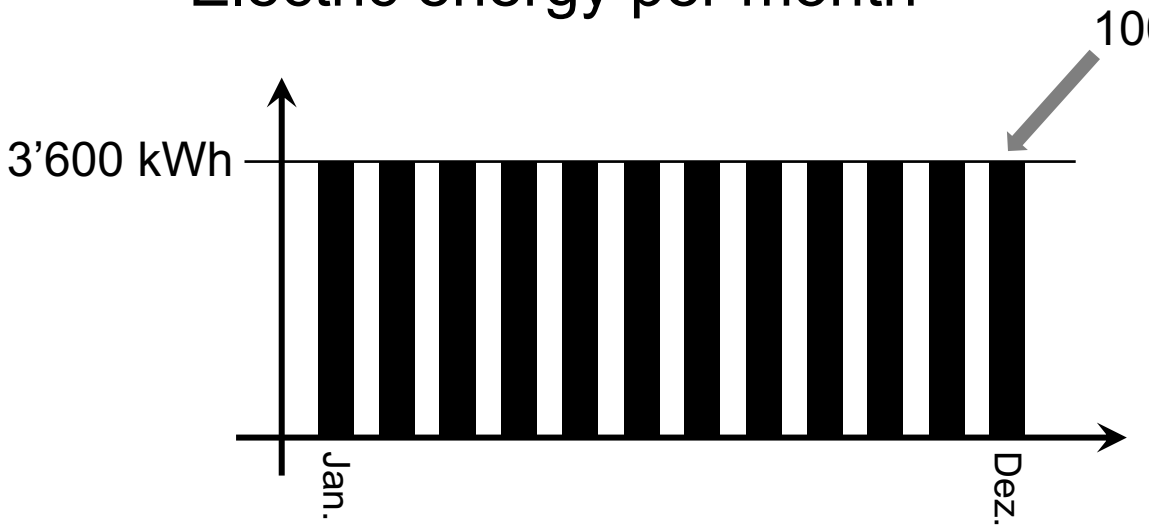
* Including all accidents (Tschernobyl, Fukushima, …)
° Including all emission at construction and reycling, … («grey» CO_2)

Load Factors

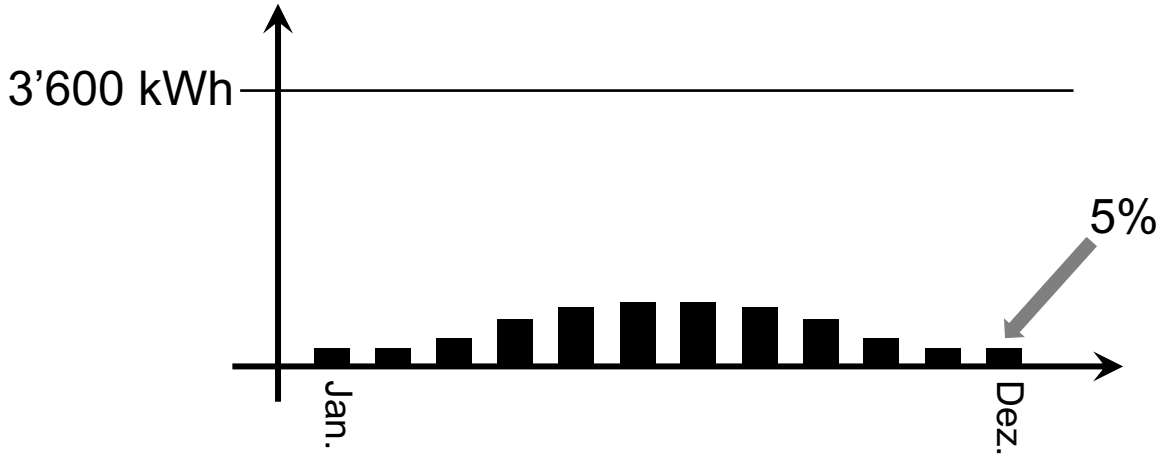
Rated power 5 kW

Rated power 5 kW

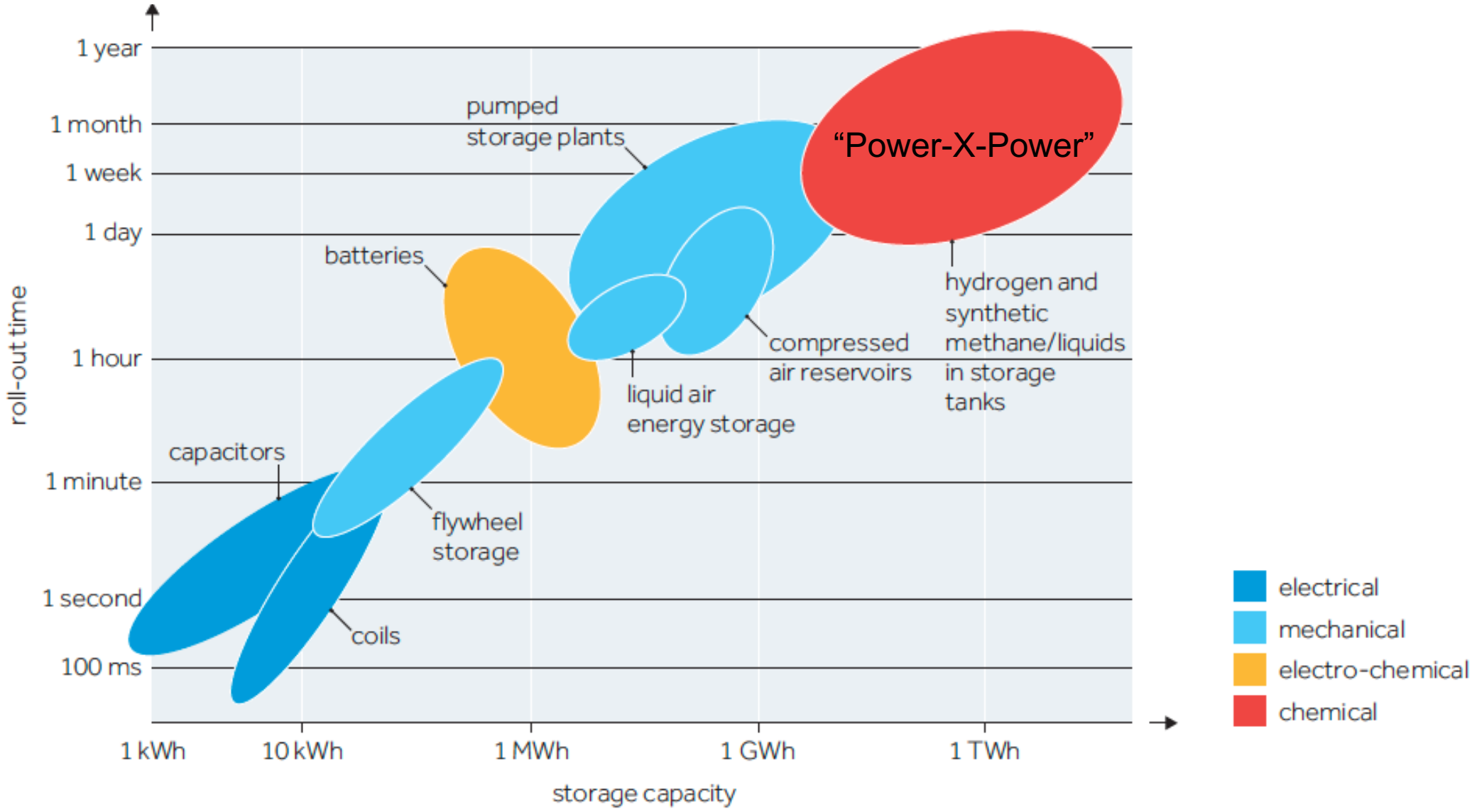
Electric energy per month



Electric energy per month



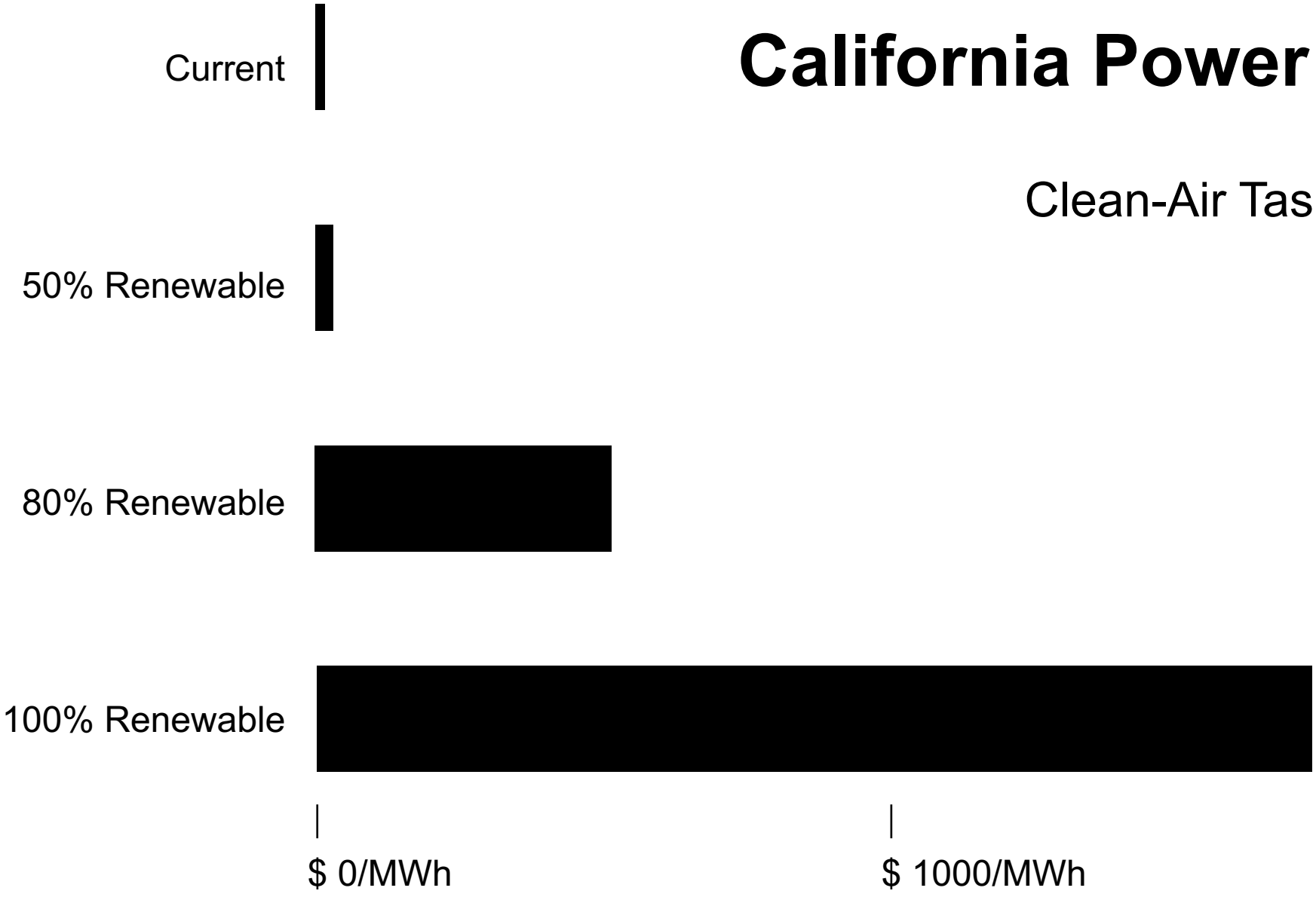
How to Store Electric Energy



M. Yugo, A. Soler. A look into the role of e-fuels in the transport system in Europe. Concave Review, vol. 28, no.1.

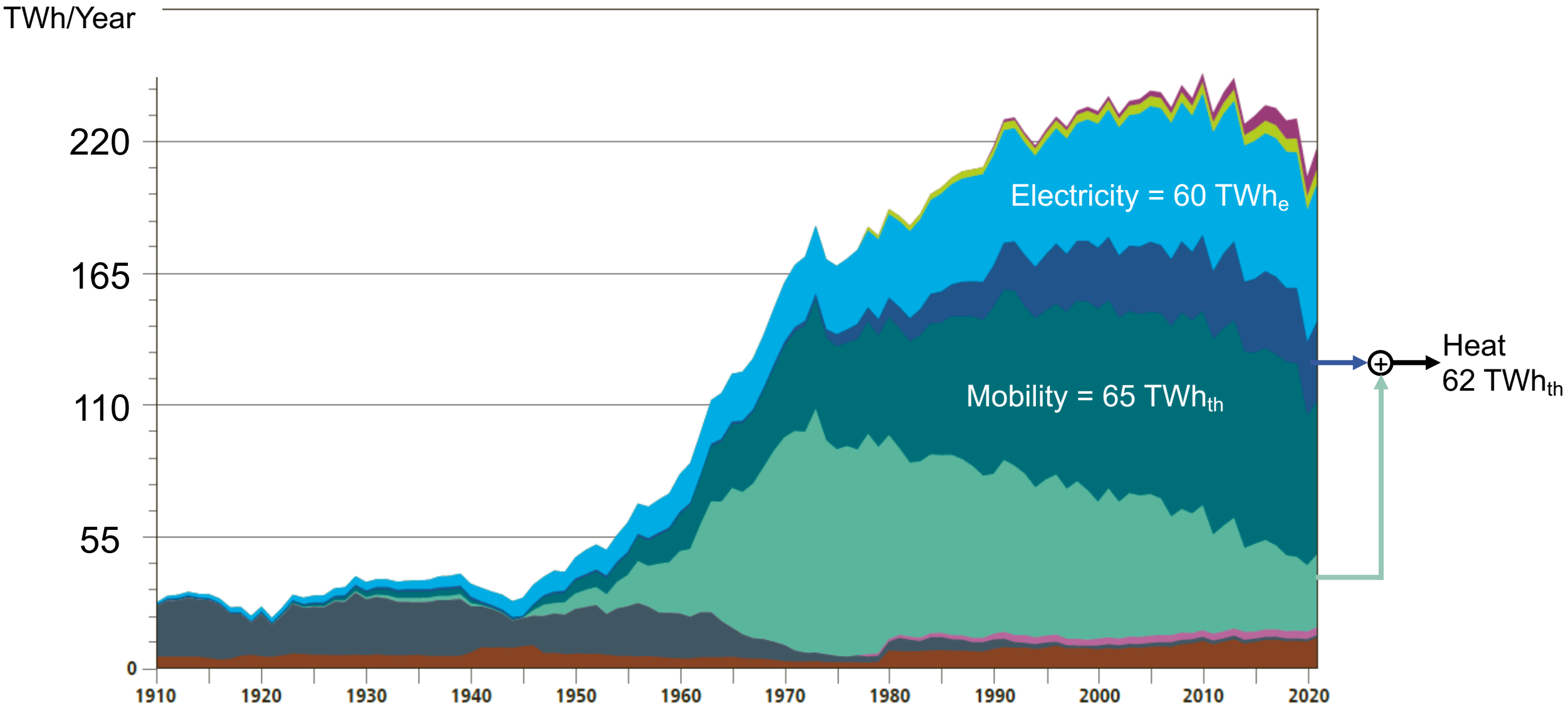
California Power System Cost

Clean-Air Task Force Report, 2018



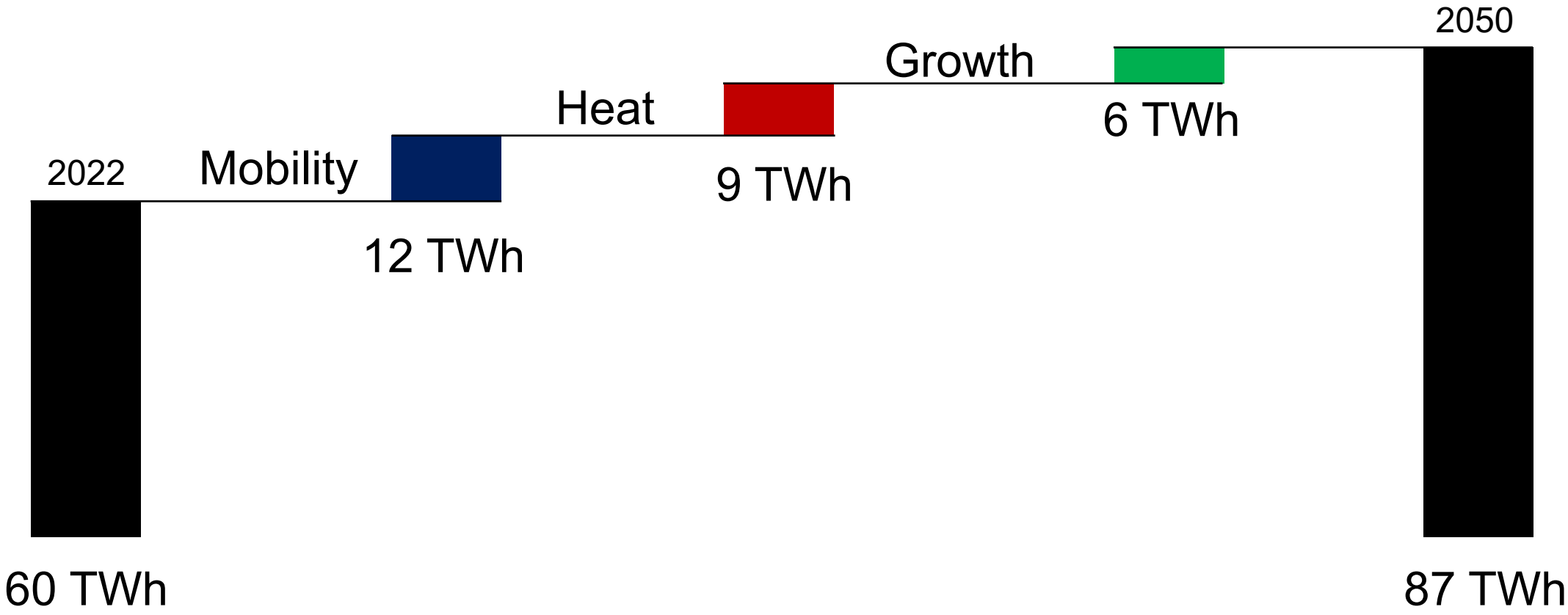
https://www.technologyreview.com/2018/07/27/141282/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/

Energy Consumption Switzerland



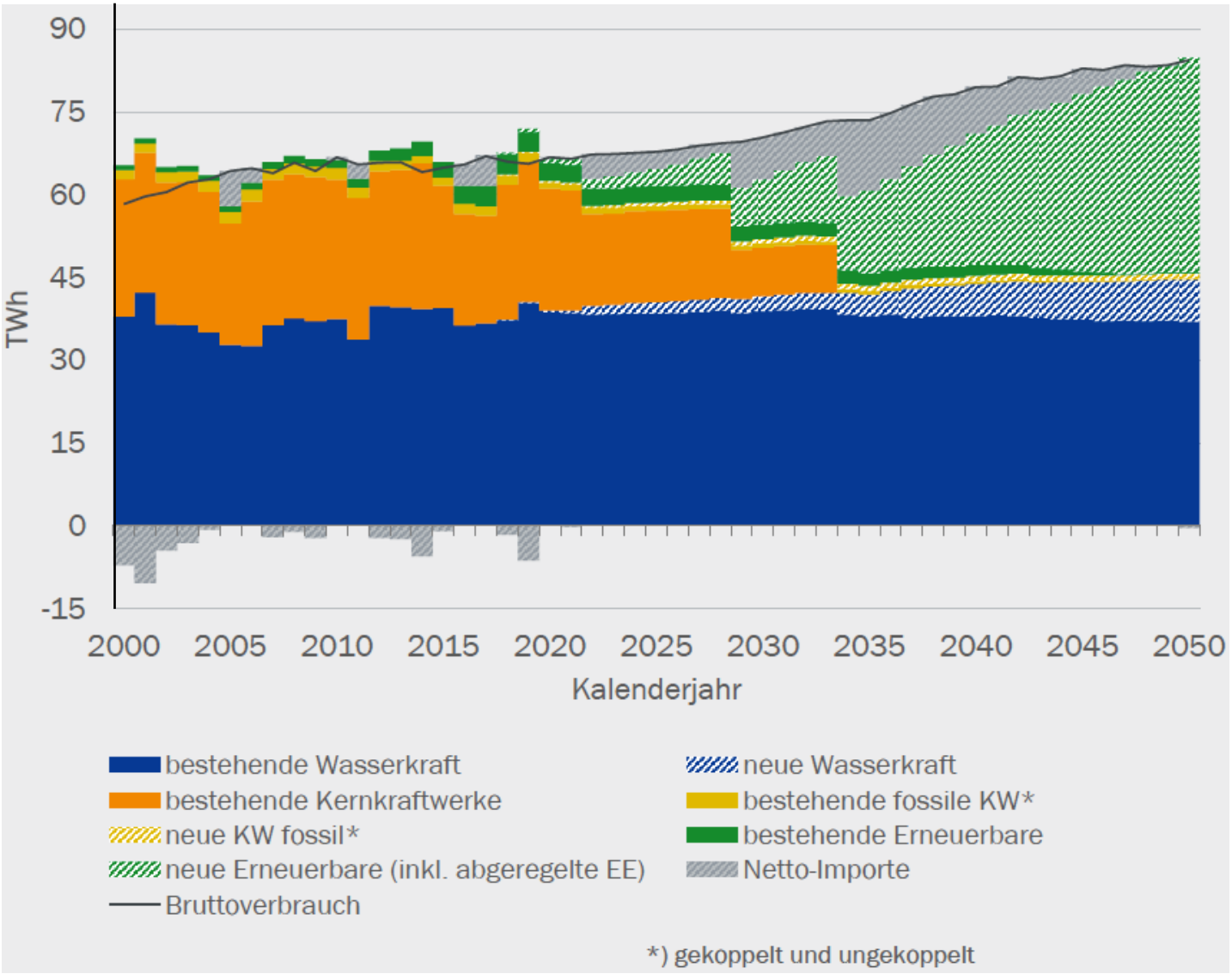
BfE, Schweizerische Gesamtenergiestatistik, 2021

Future Electricity Demand CH – 2050



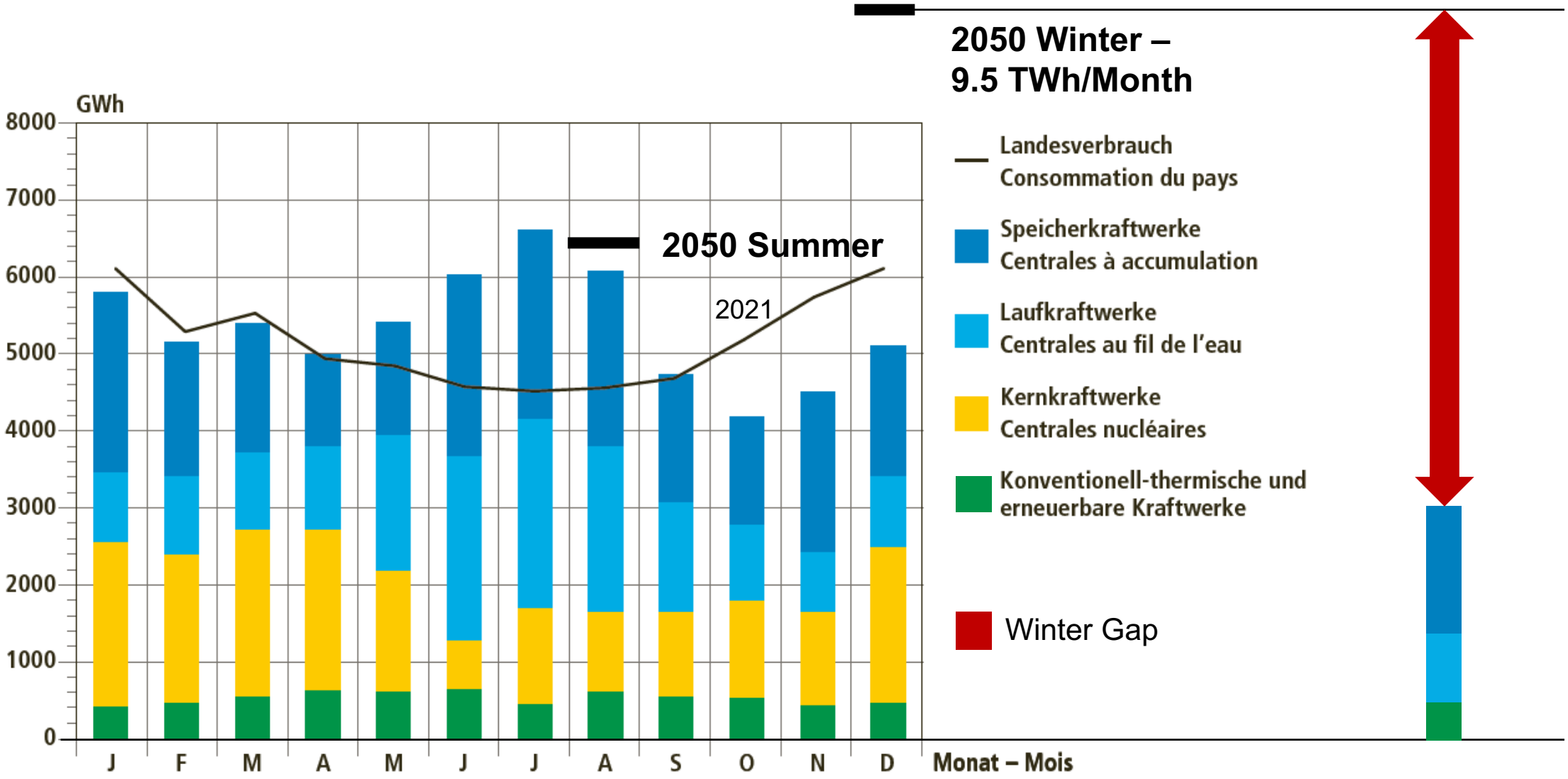
Nota bene: Average power: Sommer ≈ 9 GW, Winter ≈ 13 GW

Energy Strategy 2050



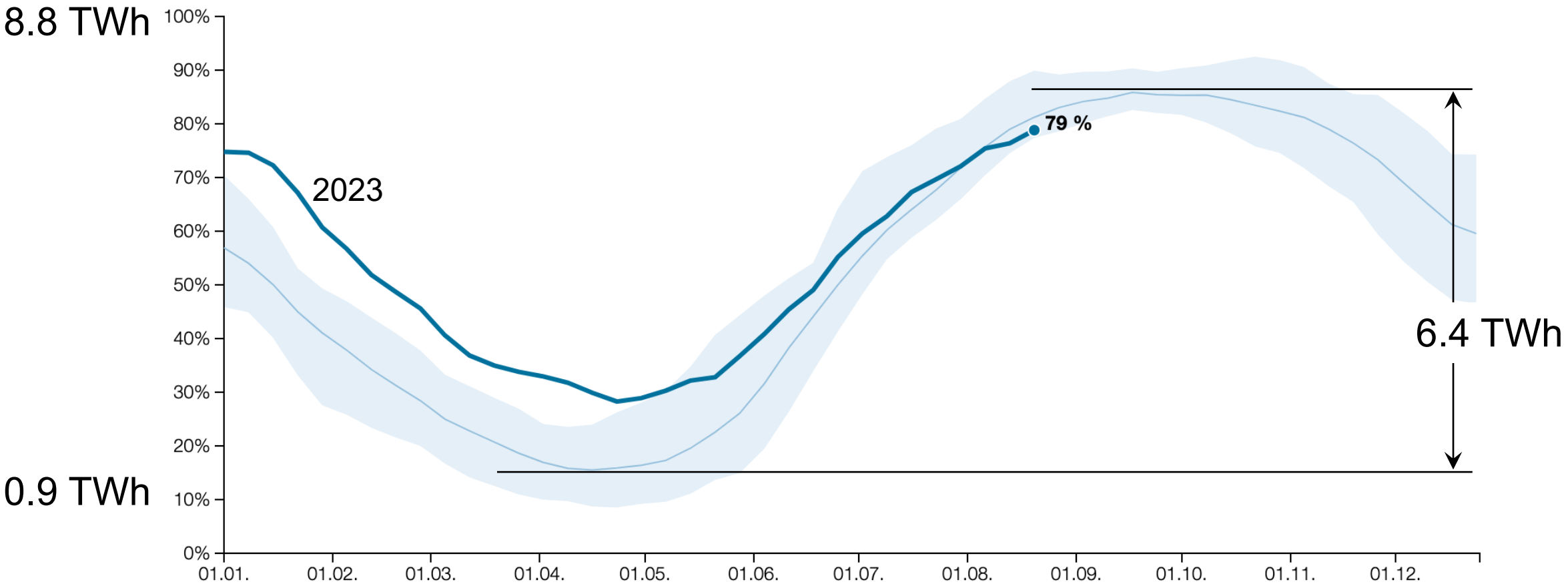
Source: «Energiestrategie 2050», Ecoplan, TEP, Infras und Prognos, 2021

Electricity CH 2021 and 2050 – Monthly Demand



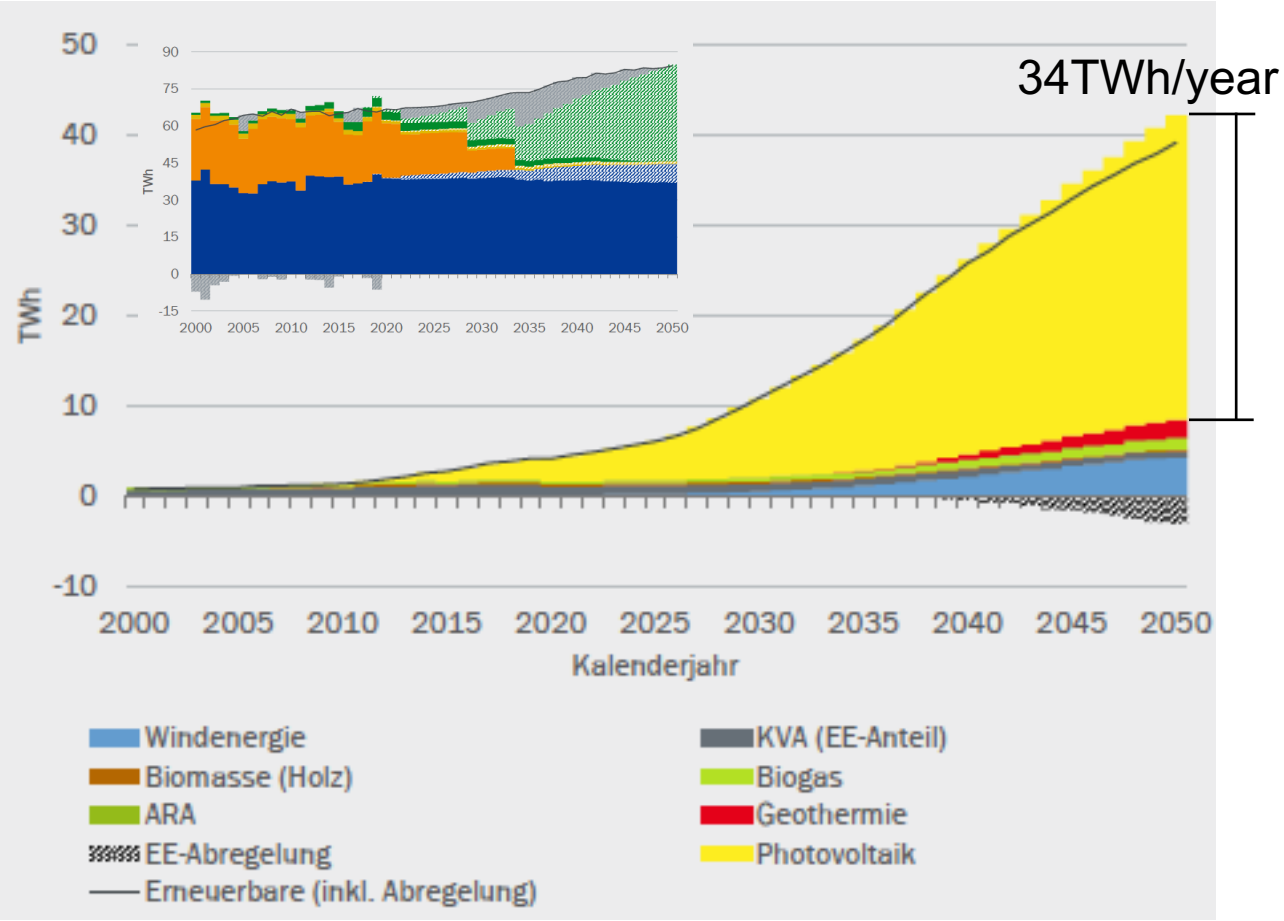
BFE, Schweizerische Elektrizitätsstatistik 2021 (Fig. 10)
OFEN, Statistique suisse de l'électricité 2021 (fig. 10)

Historic and Actual Levels CH Hydro Storage



Quelle: https://www.bfe.admin.ch/bfe/de/home/versorgung/statistik-und-geodaten/energiestatistiken/elektrizitaetsstatistik.html/

Yearly Electricity Production PV CH 2050



PV CH, Year 2020

Installed capacity 2.9 GW

Electric energy generated 2.75 TWh/year

Loadfactor:

$$2'750\ \text{GWh}/(2.9\ \text{GW} \times 365 \times 24) = 0.11$$

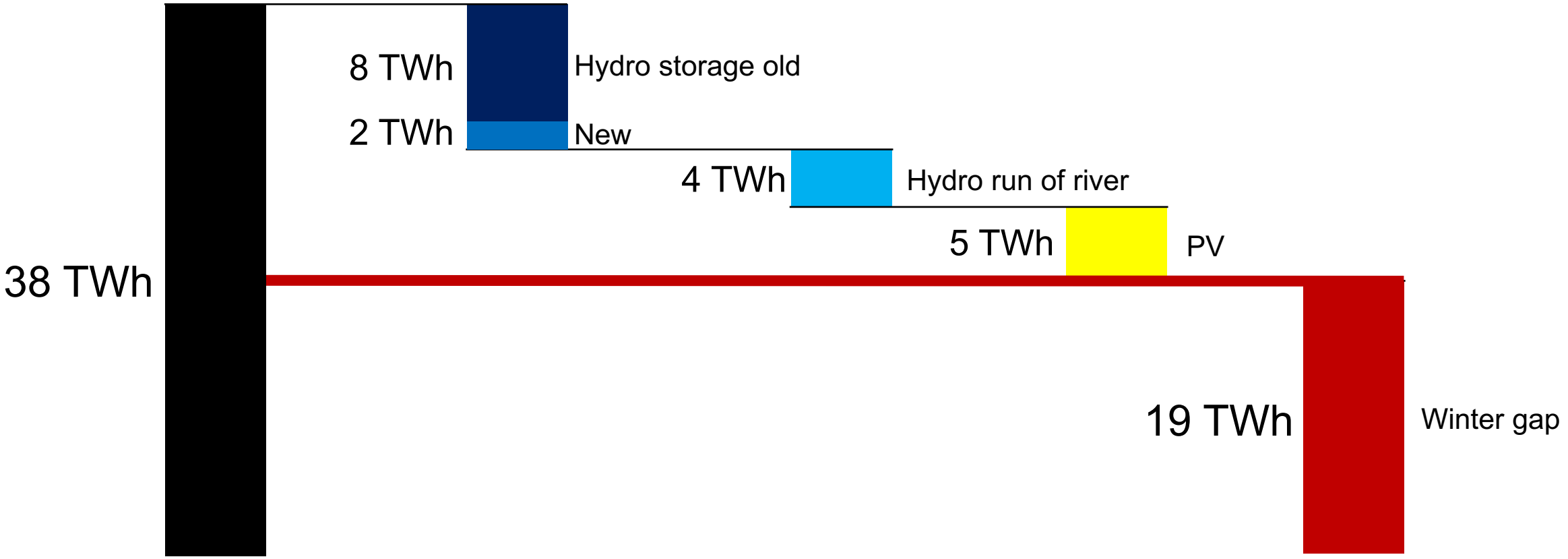
Source: Swissolar, Faktenblatt, 2021

PV CH, Year 2050

$$\frac{2.9\ \text{GW} \times 34.00\ \text{TWh}}{2.75\ \text{TWh}} = 36.0\ \text{GW}$$

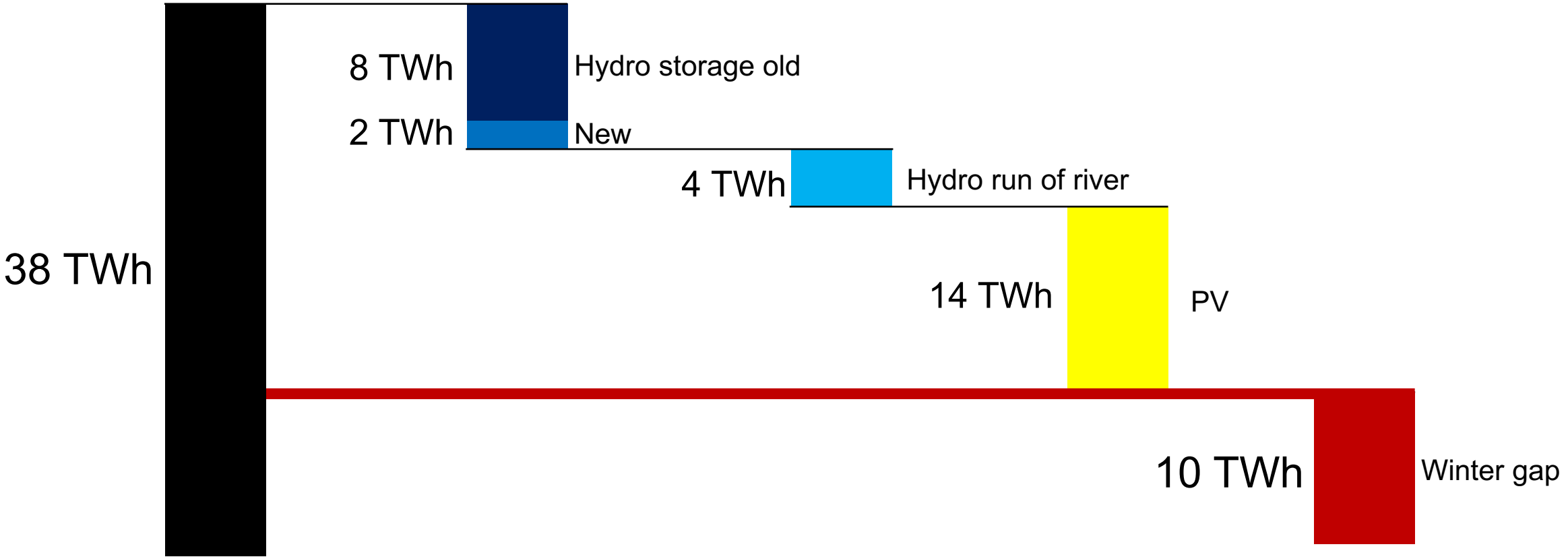
Source: «Energiestrategie 2050», Ecoplan, TEP, Infras und Prognos, 2021

CH 2050 Winter° – 36 GW PV



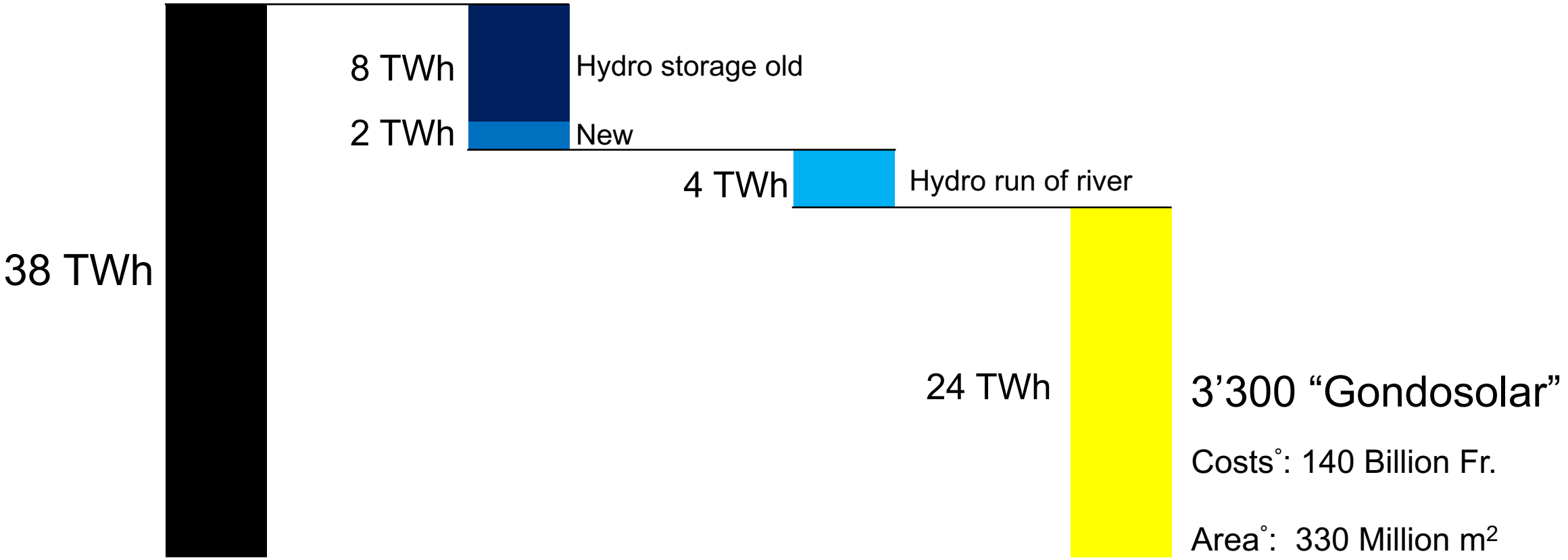
° Winter: November 1 – February 28

CH 2050 Winter – 36 GW PV in the Alps



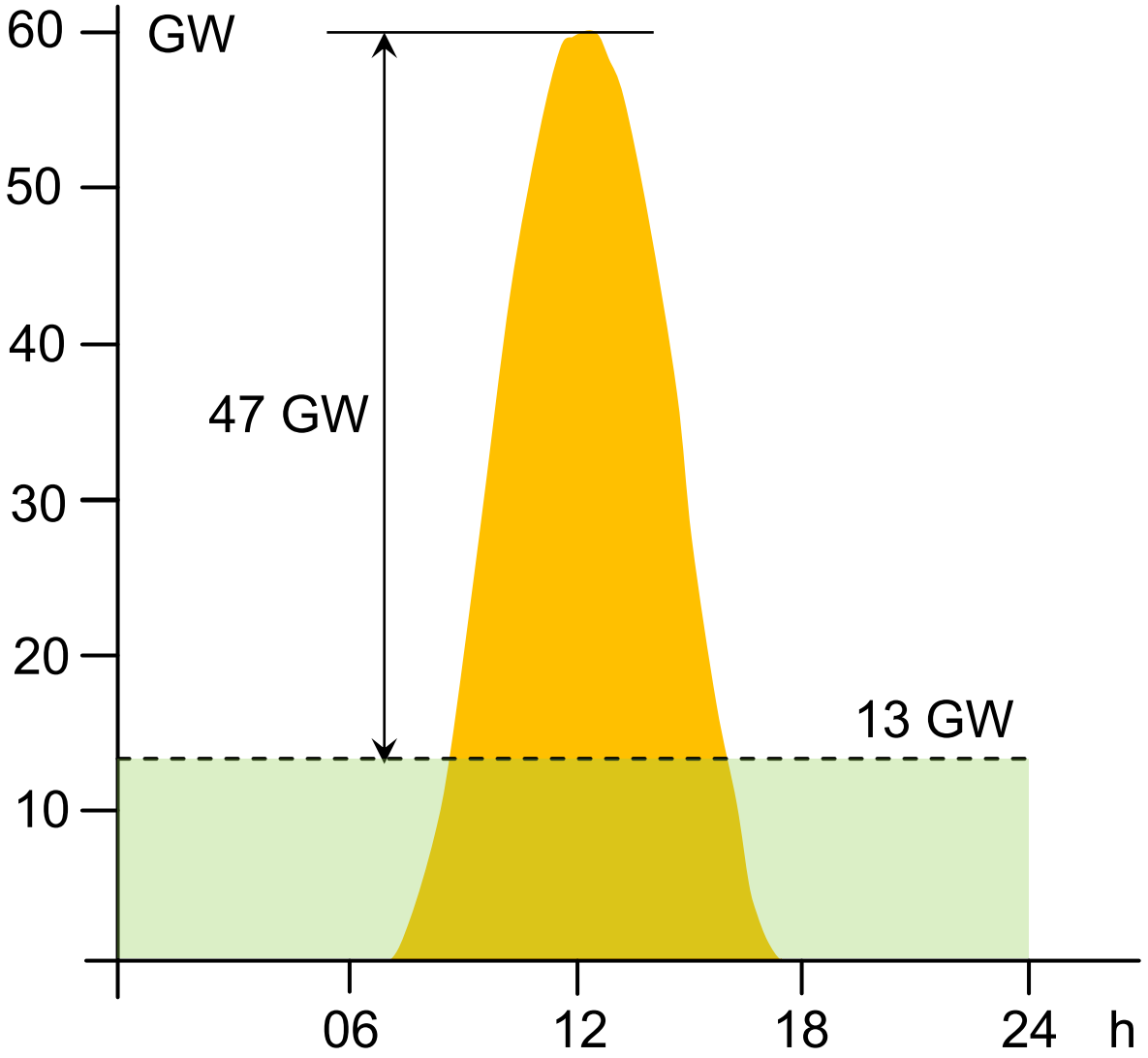
° Winter: November 1 – February 28

CH 2050 Winter – 60 GW PV in the Alps

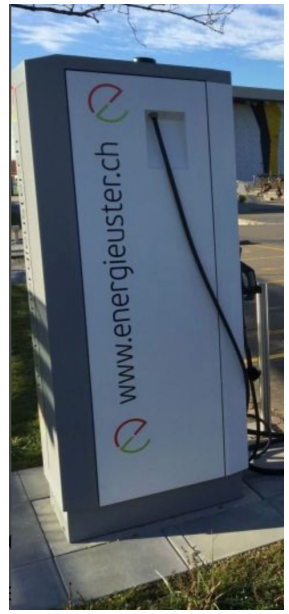


° https://www.gondosolar.ch

Daily Variations – 60 GW PV in the Alps



22 kW



47 GW / 22 kW ca. 2.1 Mio.

2022: 7271 Charging points,
Source: TCS

- The world needs much more energy
- The emission of greenhouse gases must be priced
- Ambitious goals are good, concrete improvements are better, technology taboos are bad
- It’s the economy that decides
- Research yields the best return of investment
- Attract talented people to science, engineering, and economics

Thank you for your attention!

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