“Schweizer Tourismus mit erneuerbarer Energie”

SKÅL International Bern
Hotel Ambassador
Seftigenstrasse 99, 3007 Bern
22. Juni 2023

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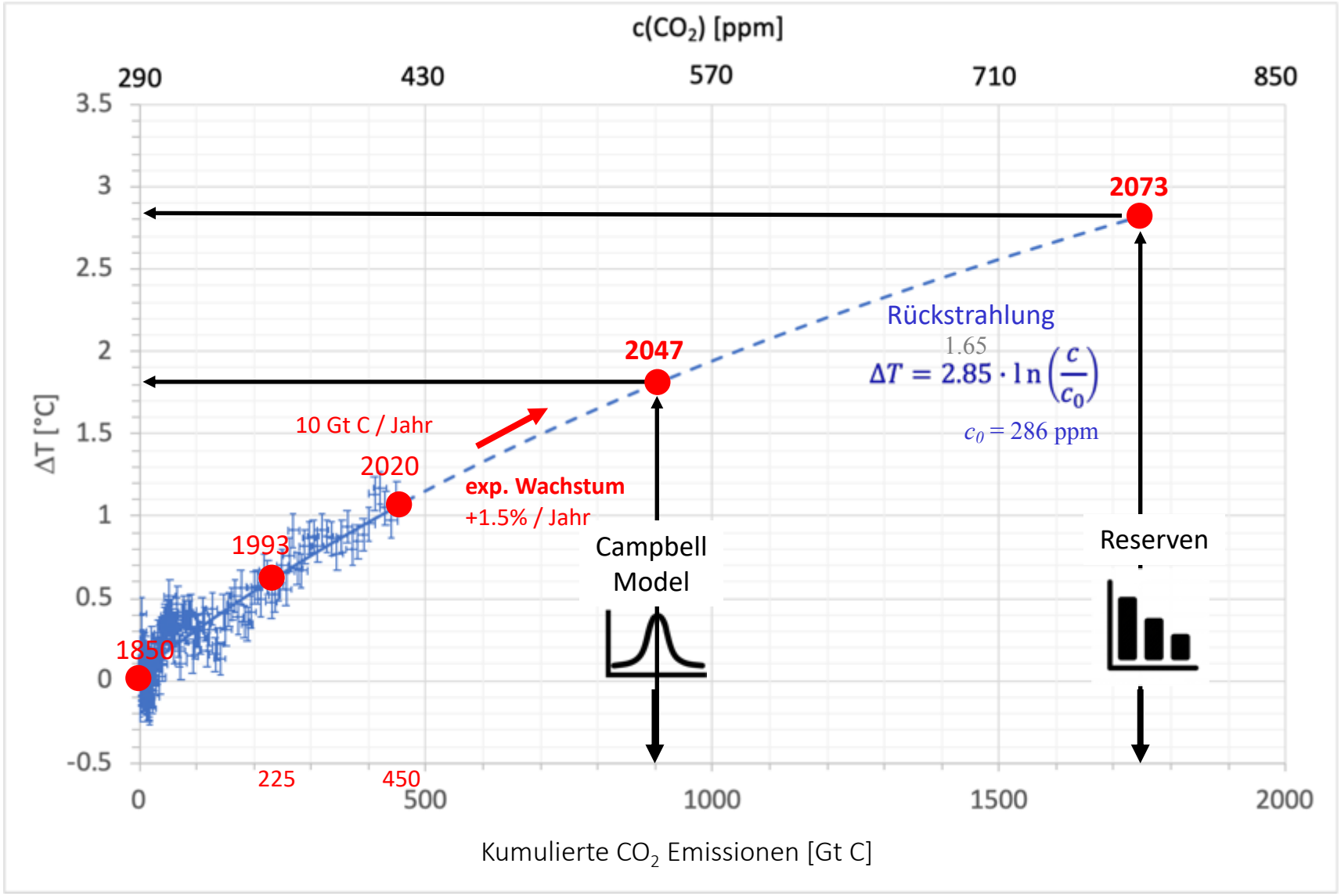
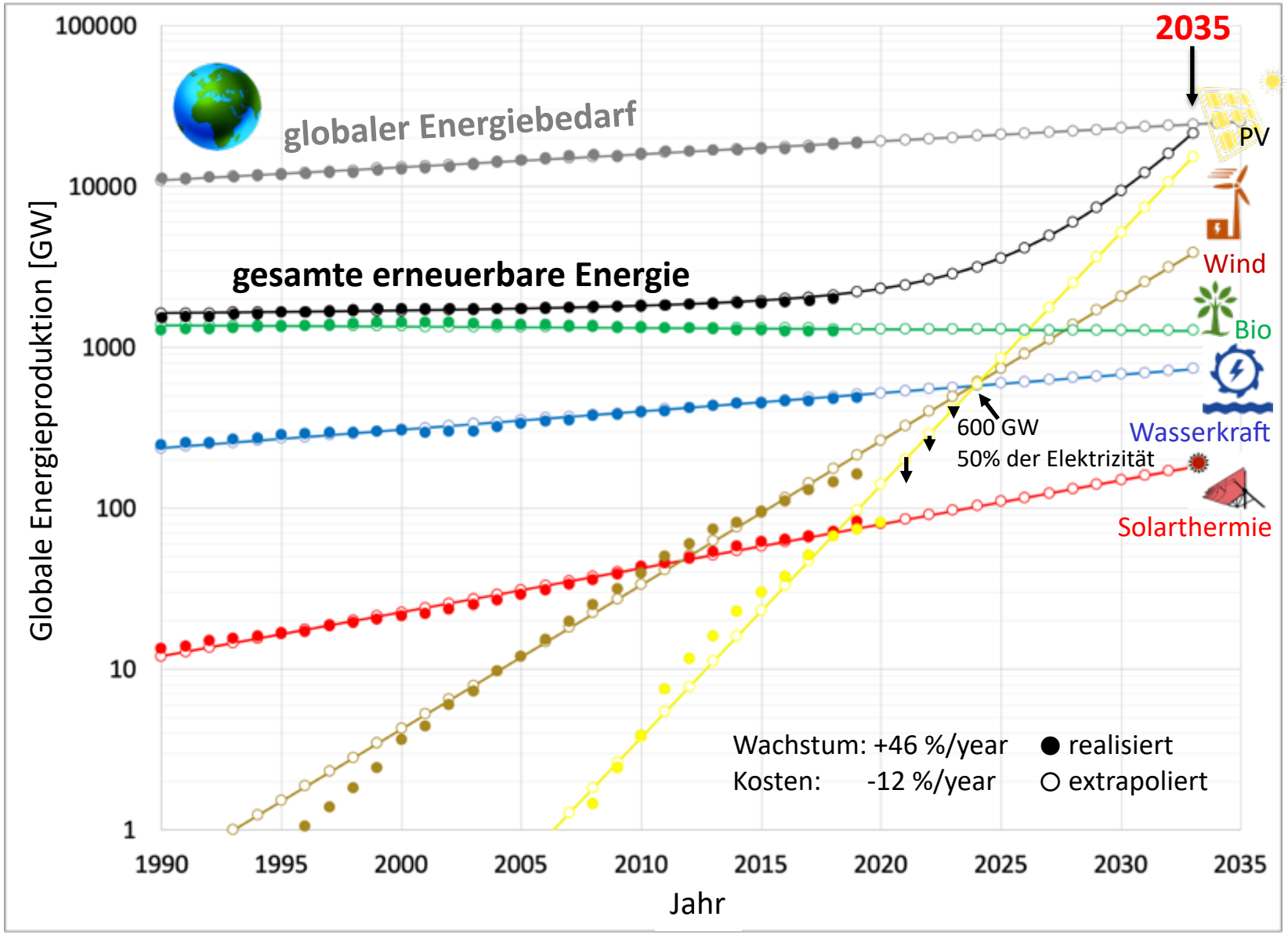
Globale Erwärmung vs. kumulierte CO_2 Emissionen



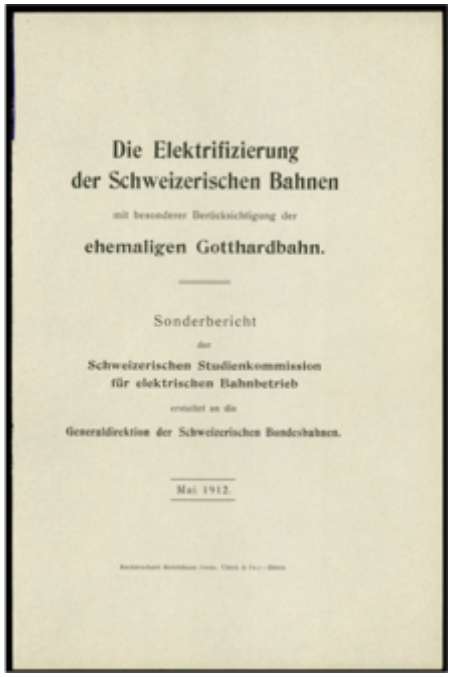
Ref.: http://www.globalwarmingequation.info/global%20warming%20eqn.pdf and Ollila, A. (2014), "The potency of carbon dioxide (CO_2) as a greenhouse gas", Development in Earth Science, Vol. 2, pp. 20-30, available at: www.seipub.org/des/paperInfo.aspx?ID=17162

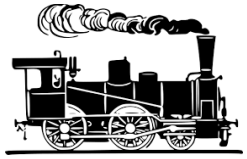
Globale erneuerbare Energieproduktion



Ref.: https://ourworldindata.org/energy

Entscheidung die Kohle durch Elektrizität zu ersetzen 1912

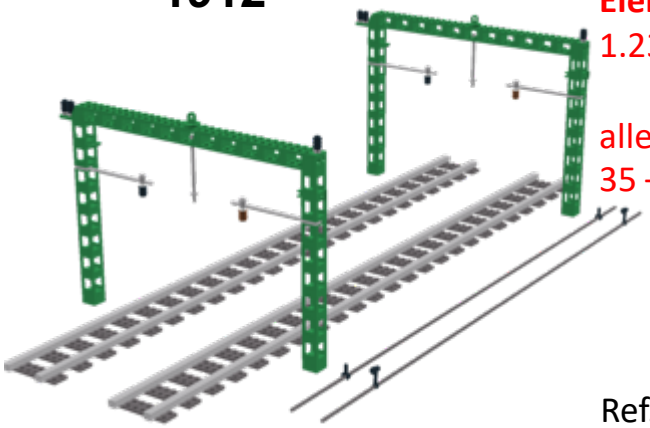

Die Elektrifizierung
der Schweizerischen Bahnen
mit besonderer Berücksichtigung der
ehemaligen Gotthardbahn.
Sonderbericht
der
Schweizerischen Studienkommission
für elektrischen Bahnbetrieb
erstattet an die
Generaldirektion der Schweizerischen Bundesbahnen.
Mai 1912.



1912

Ref.: "Die Elektrifizierung der Schweizerischen Bahnen mit besonderer Berücksichtigung der ehemaligen Gotthardbahn.", Sonderbericht der Schweizerischen Studienkommission für elektrischen Bahnbetrieb erstattet an die Generaldirektion der Schweizerischen Bundesbahnen. Mai 1912.

1912



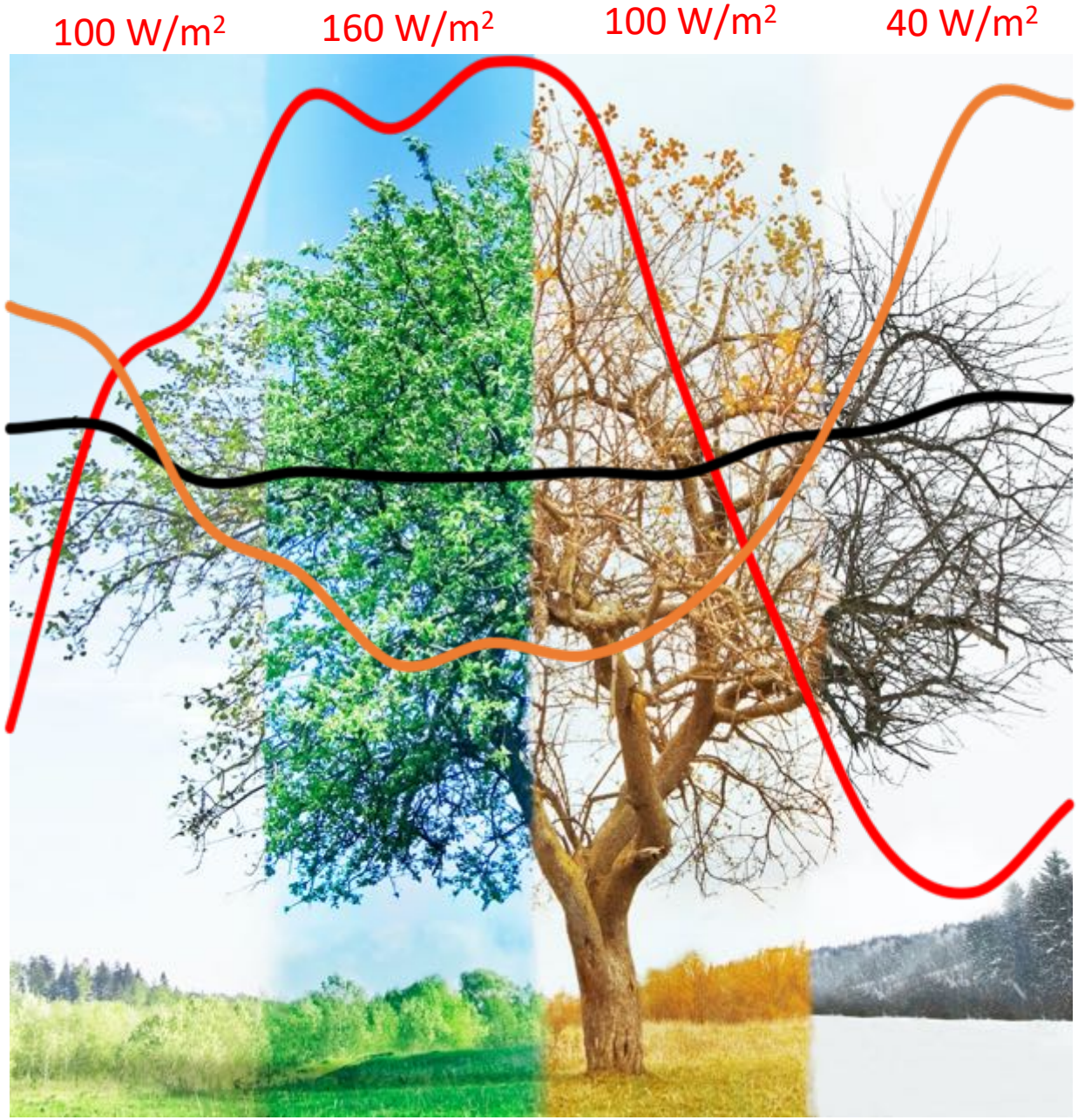
Elektrifizierung
1.23 – 2.6 MCHF/km

alle 27m ist ein Mast
35 – 70 kCHF pro Mast

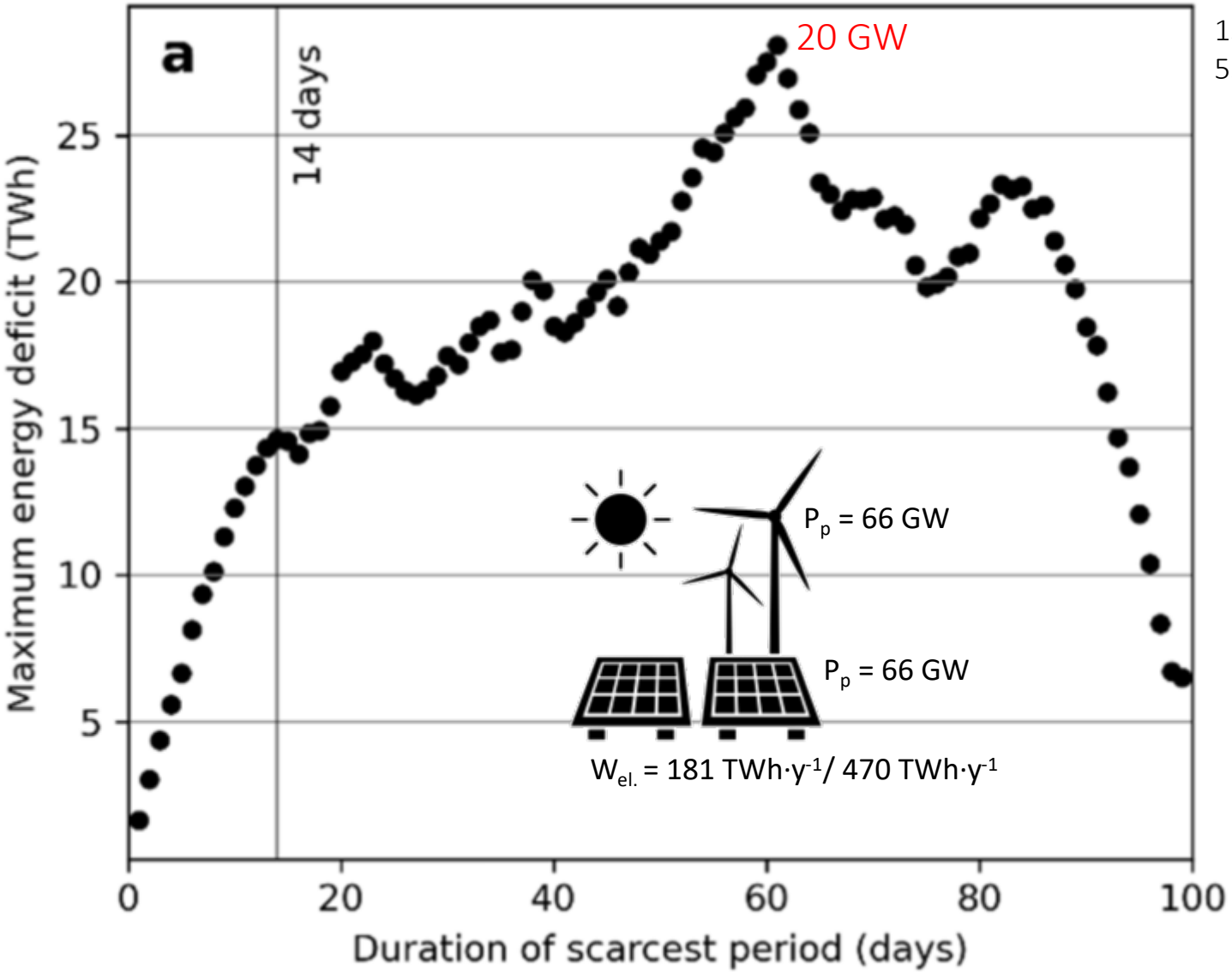
Schienen Kosten 62 MCHF/km
(Autobahn Kosten 150 - 330 MCHF/km)

Ref.: Deutschland: Lindau - München 500 MCHF für 189 km incl. Lärmschutz, neuer Bahnhof...
Dänemark: Elektrifizierung 1'600 MCHF für 1300 km

Saison in der Schweiz



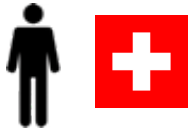
Fehlende Elektrizität über die letzten 35 Jahre



150 GW_p installed
53 GW avg. Power

Ref.: Oliver Ruhnau, and Staffan Qvist,"Storage requirements in a 100% renewable electricity system: extreme events and inter-annual variability", Environ. Res. Lett. 17 (2022) 044018, https://doi.org/10.1088/1748-9326/ac4dc8

Die Schweizer Energiewirtschaft 2019



3.2 kW

0.35 kW

23 TWh·y^{-1}

1.65 kW

122 TWh·y^{-1}

H_2

47 TWh·y^{-1}

0.27 kW

20 TWh·y^{-1}

0.32 kW

23 TWh·y^{-1}

0.89 kW

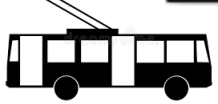
66 TWh·y^{-1}

8 TWh·y^{-1}

35 TWh·y^{-1}

0.58 kW

43 TWh·y^{-1}

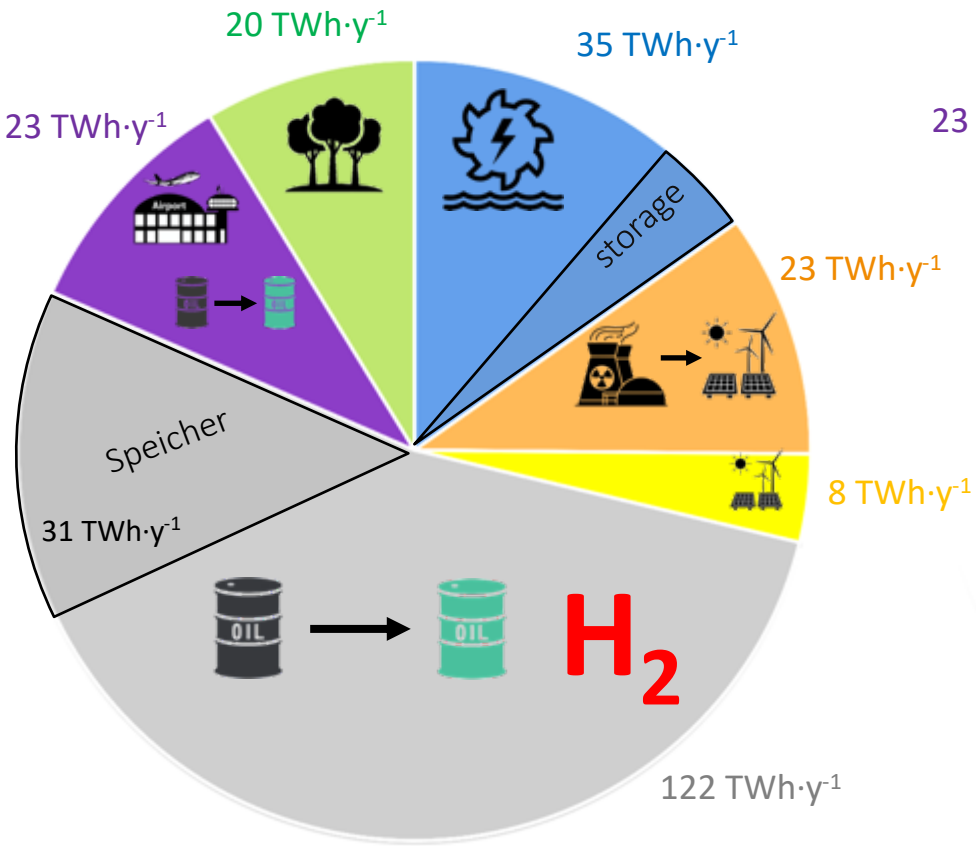


total 232 TWh·y^{-1}

total 156 TWh·y^{-1} (-33%)

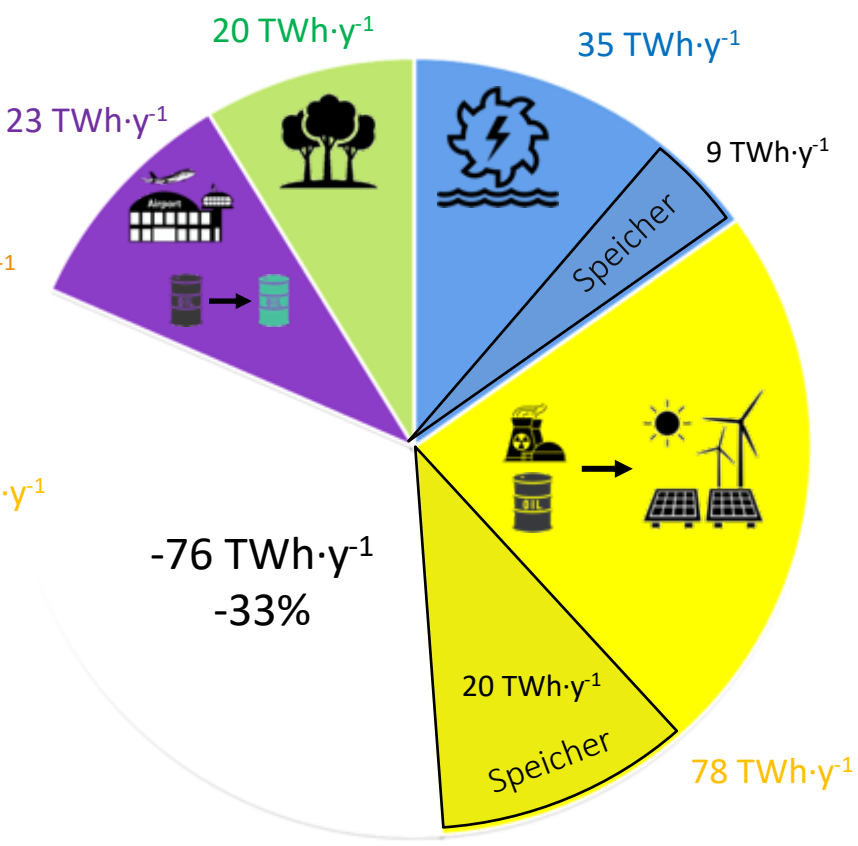
Der Schweizer Energiebedarf 2019

Energiebedarf (2019)



232 TWh·y^{-1}

Elektrifizierung



156 TWh·y^{-1}

Ref.: SCHWEIZERISCHE GESAMTENERGIE STATISTIK (2019) Art.-Nr. 805.006.19 / 08.20 / 1200 / 860467013, Federal Office of Energy, Switzerland, https://www.bfe.admin.ch/bfe/de/home/versorgung/statistik-und-geodaten/energiestatistiken/gesamtenergiestatistik.exturl.html/

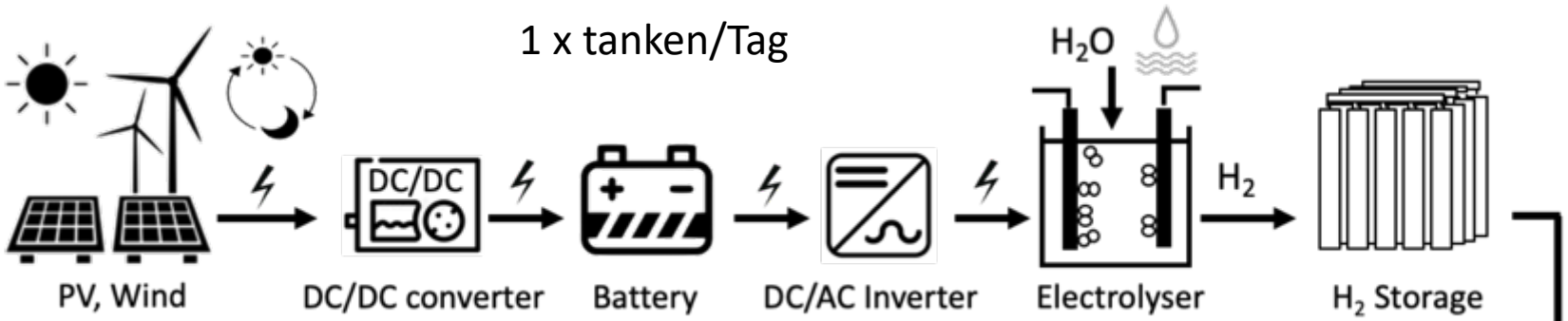
Erneuerbare Energiewirtschaft

	Elektrizität	Wasserstoff	Syn. Öl
	3669.-	5683.-	9712.-
23 TWh·y^{-1}	1 x 75 GWh 316.- 4 x		
121 TWh·y^{-1}, 47 TWh·y^{-1}	2 x 134 km^2 150 GWh 642.- 9 x 1.5 TWh	6 x 480 GWh 2656.- 2 Mm^3 200 bar 25 x	12 x 920 GWh 6684.- 159 L 94 Mio.
23 TWh·y^{-1}			2 x 140 GWh 1212.- 14 Mio.
existierende PV, Biomasse, Wasserkraft 63 TWh·y^{-1}	1500.- 8 TWh·y^{-1} 20 TWh·y^{-1} 35 TWh·y^{-1}		

Synthetische Treibstoffe für den Flugverkehr

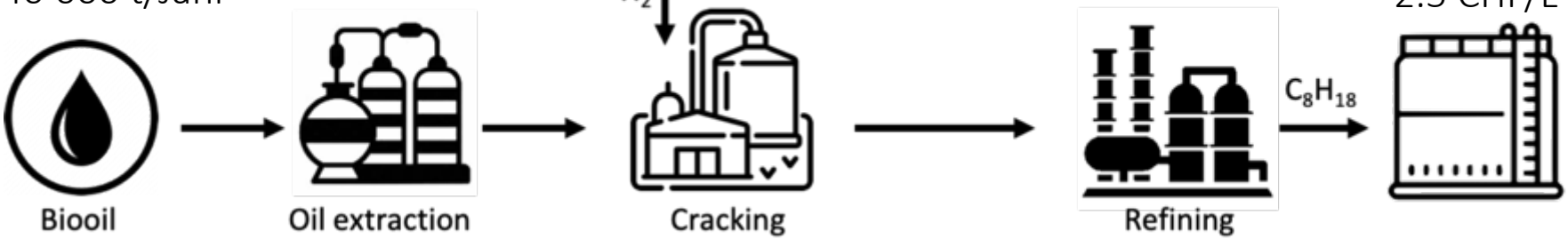
104 km^2

1 x tanken/Day



3 km^2

40’000 t/Jahr



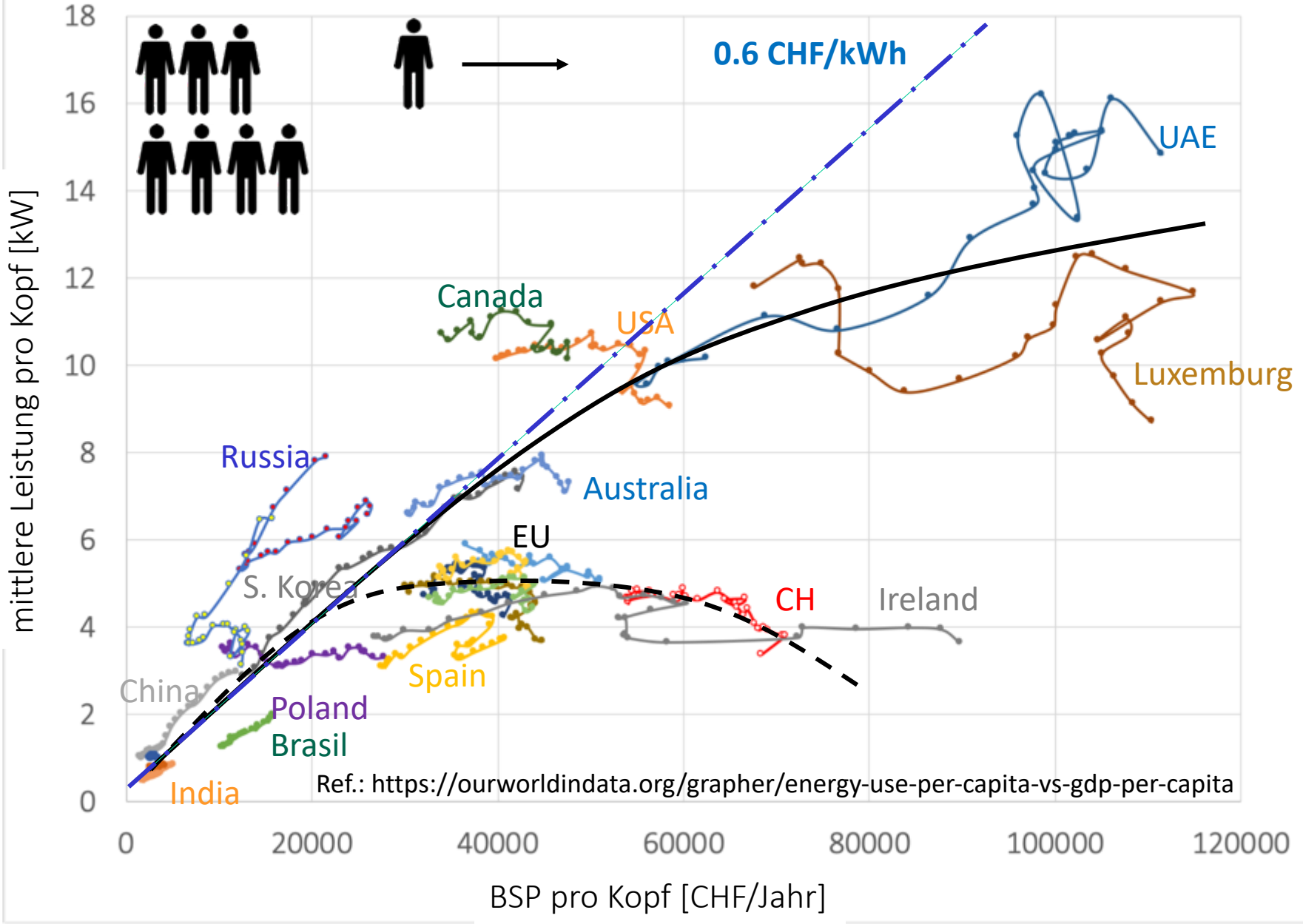
2.5 CHF/L

Stauseen in den Alpen

Stauseen in den Alpen

Regulierung des Wasserabflusses

Energie und Wirtschaft



Erneuerbare Energie für die Welt

Albanese vows to transform Australia into clean energy 'superpower'

Incoming Australian prime minister Anthony Albanese has promised to make the nation a "renewable energy superpower" in the wake of Labor's federal election victory at the weekend.

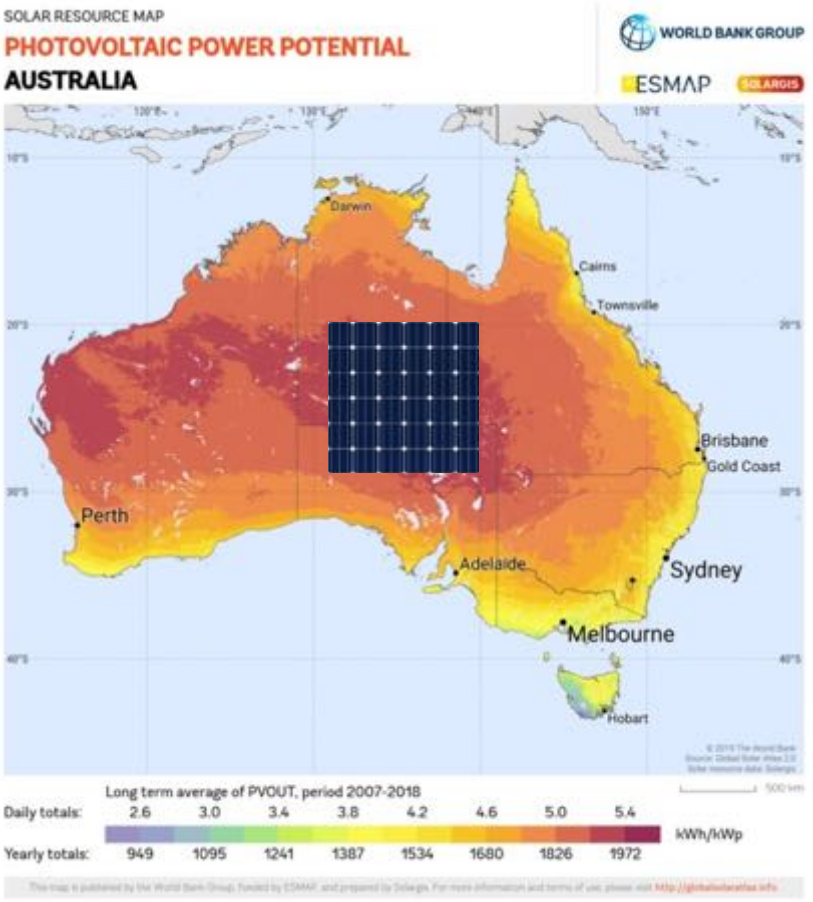
MAY 23, 2022 DAVID CARROLL

MARKETS & POLICY | POLICY | SUSTAINABILITY | AUSTRALIA

Anthony Albanese is promising an end to the "climate wars".

Image: Facebook

Landfläche, Sonnenintensität, Saison

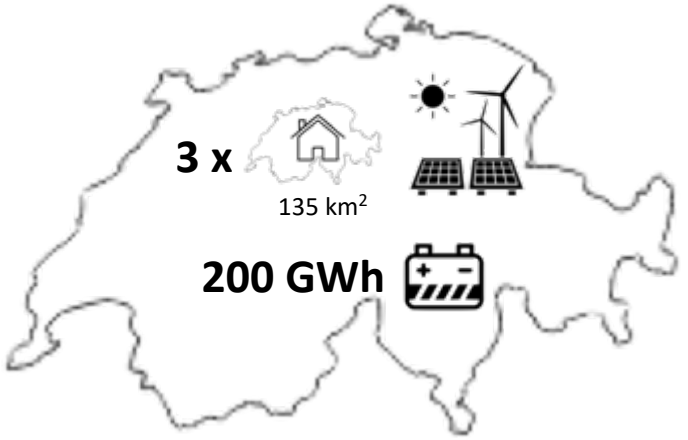


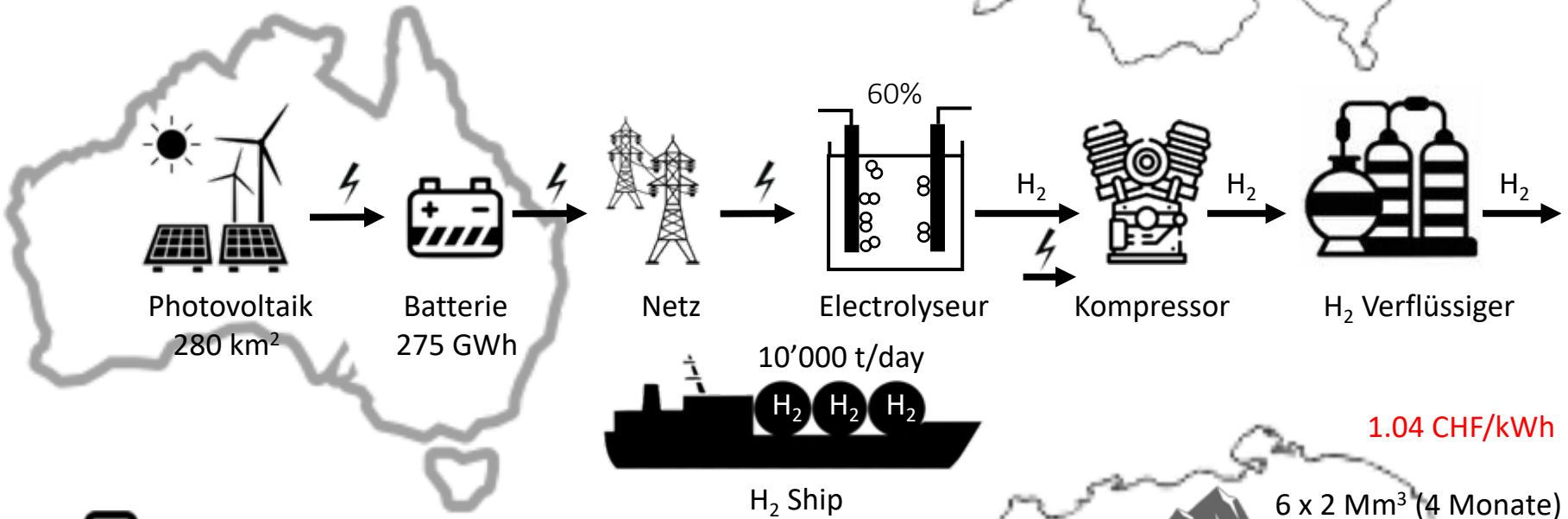
20 TW as H_2 $(1000\ km)^2$

18 GW as H_2 $(30\ km)^2$

Wasserstoff produziert in Australien

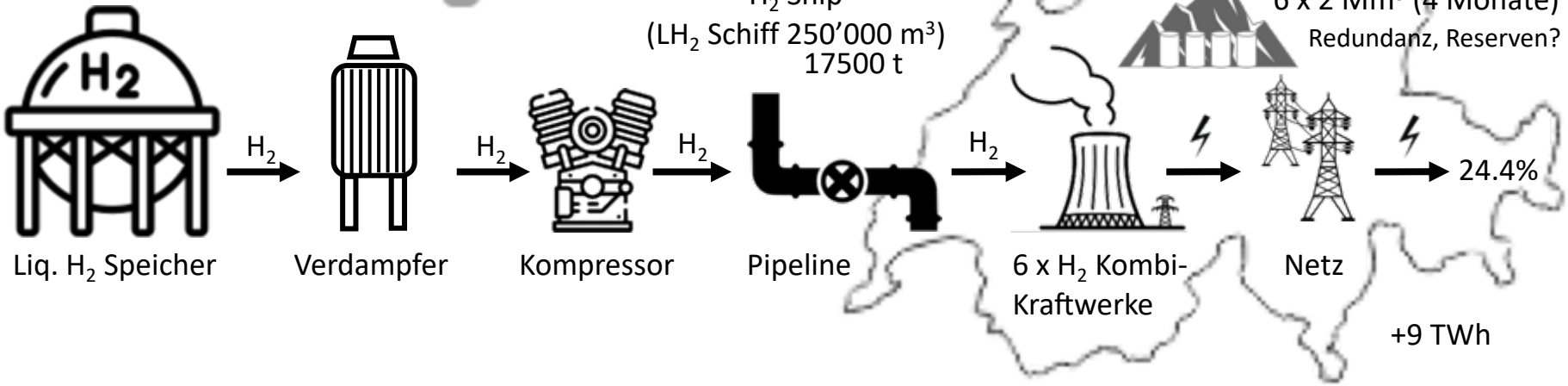
Wasserstoff Import für die Kombikraftwerke während 4 Monaten zur Produktion von Elektrizität und Wärme.





H_2 Ship
(LH_2 Schiff 250'000 m³)
17500 t

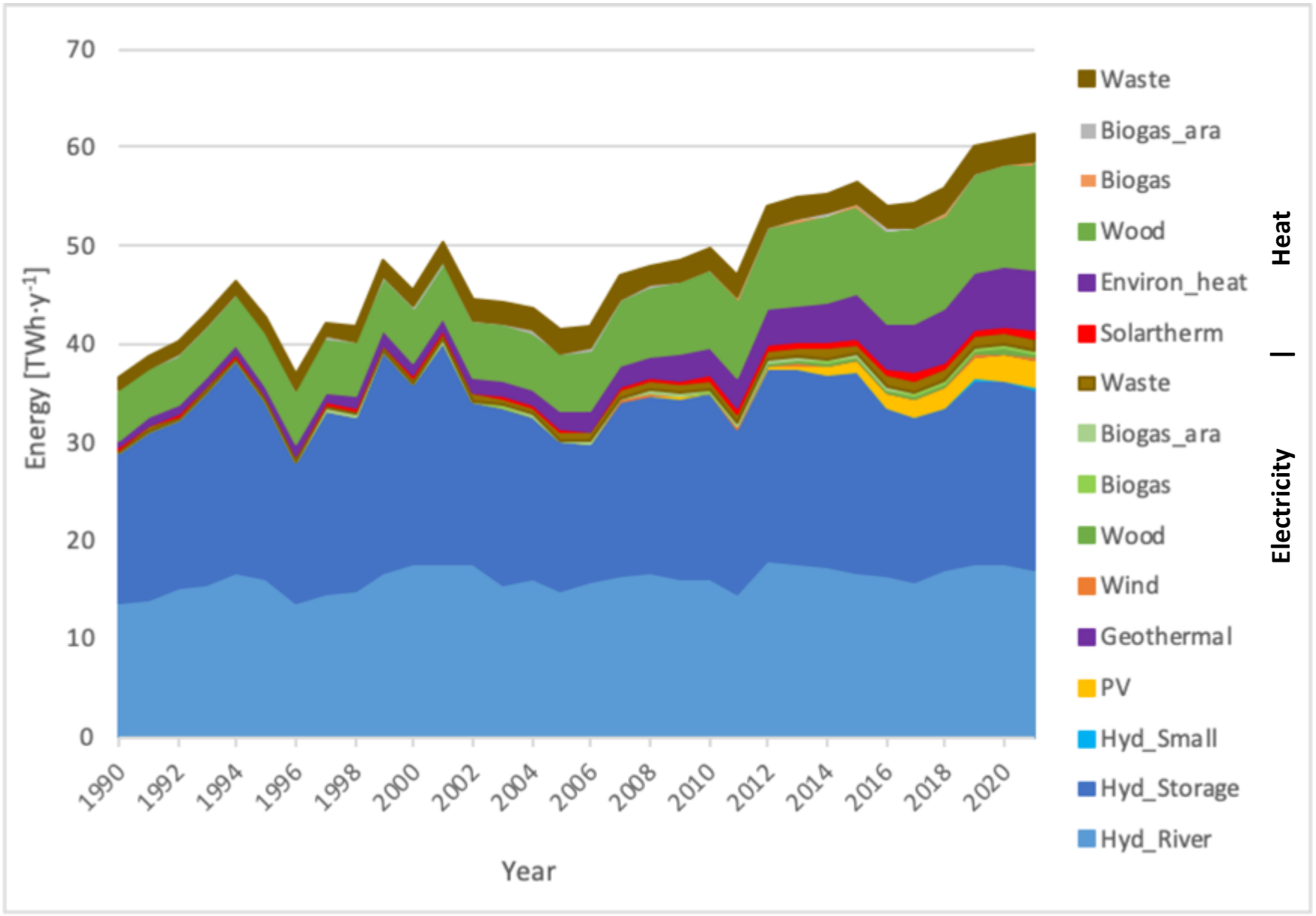
1.04 CHF/kWh



Haus mit Brennstoffzelle

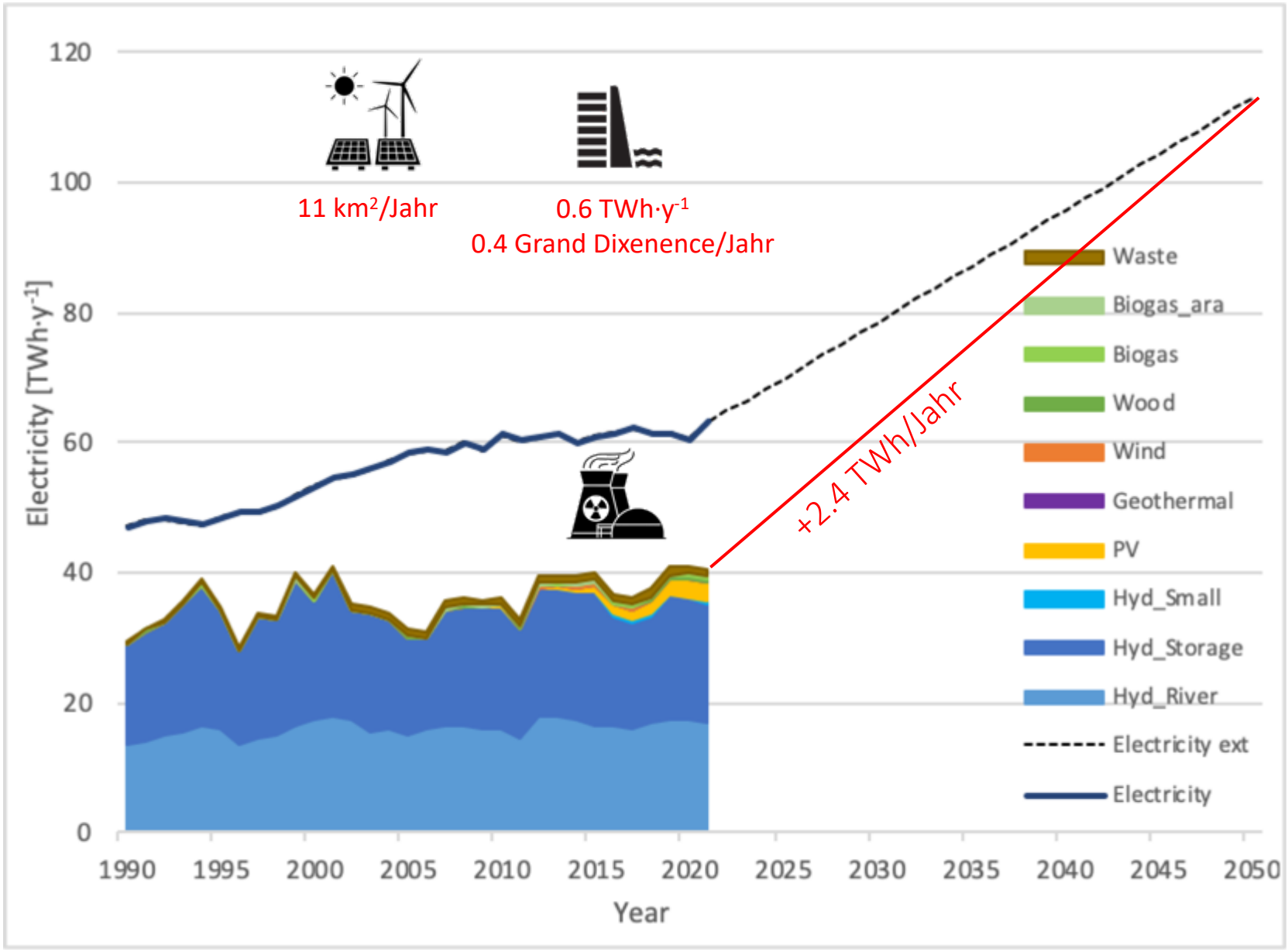
Im Winter wird aus Wasserstoff Elektrizität (50%) und Wärme (50%) in der Brennstoffzelle erzeugt.

Erneuerbare Energieproduktion in der Schweiz



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

Erneuerbaren Energieproduktion und Speicherung



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

frontiers in Energy Research

ORIGINAL RESEARCH
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Future Swiss Energy Economy: The Challenge of Storing Renewable Energy

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Fossil fuels and materials on Earth are a finite resource and the disposal of waste into the air, on land, and into water has an impact on our environment on a global level. Using Switzerland as an example, the energy demand and the technical challenges, and the economic feasibility of a transition to an energy economy based entirely on renewable energy were analyzed. Three approaches for the complete substitution of fossil fuels with renewable energy from photovoltaics called energy systems (ES) were considered, i.e., a purely electric system with battery storage (ELC), hydrogen (HYS), and synthetic hydrocarbons (HCR). ELC is the most energy efficient solution; however, it requires seasonal electricity storage to meet year-round energy needs. Meeting this need through batteries has a significant capital cost and is not feasible at current rates of battery production, and expanding pumped hydropower to the extent necessary will have a big impact on the environment. The HYS allows underground hydrogen storage to balance seasonal demand, but requires building of a hydrogen infrastructure and applications working with hydrogen. Finally, the HCR requires the largest photovoltaic (PV) field, but the infrastructure and the applications already exist. The model for Switzerland can be applied to other countries, adapting the solar irradiation, the energy demand and the storage options.

Keywords: renewable energy, photovoltaic, batteries, hydrogen, synthetic hydrocarbons, energy economy

Abbreviations: ES, energy systems; ELC, substitution of fossil fuels through electrification; HYS, substitution of fossil fuels by hydrogen; HCR, substitution of fossil fuels by synthetic hydrocarbons; PV, photovoltaics; CO_2, carbon dioxide; kWh/year, kilowatt hours per year = terawatts·10^{-9} kW/TW·365 day/year·24 h/day; GW_p, gigawatt peak; TW_p, terawatt peak; <P>, average power; W, annual energy per year; I, annual solar irradiation; η, efficiency; A, PV surface area; P_p, PV peak power; P_{avg}, average power; <P>/P_p, power factor; C, capital cost (CAPEX); Z, interest; P_b, annual payback; n, number of years; C_E, cost of the energy per energy unit; E_y, annual energy received from the energy system; OPEX, operational cost; C_y, cost of the energy.

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