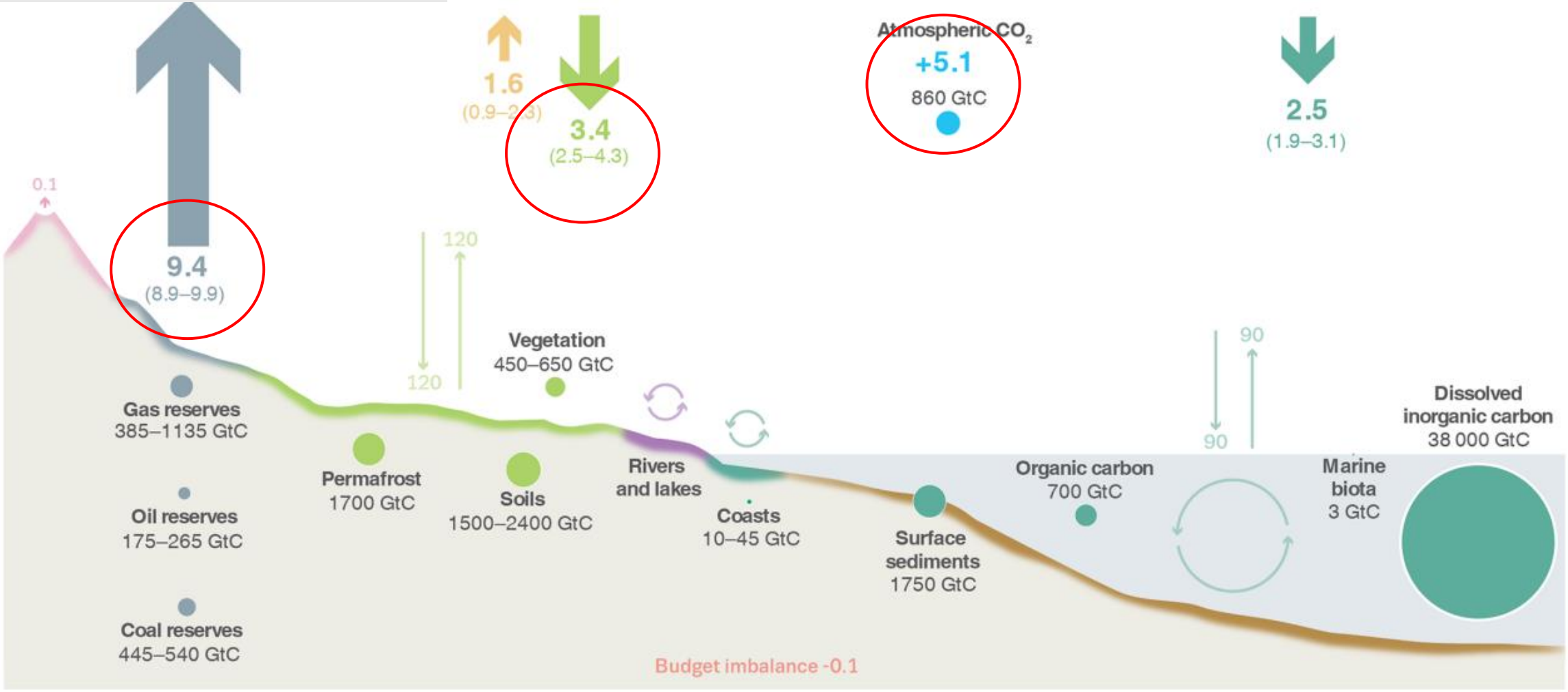
Kohlenstoff und Materialien - Chancen für Innovation

Rupert Wimmer

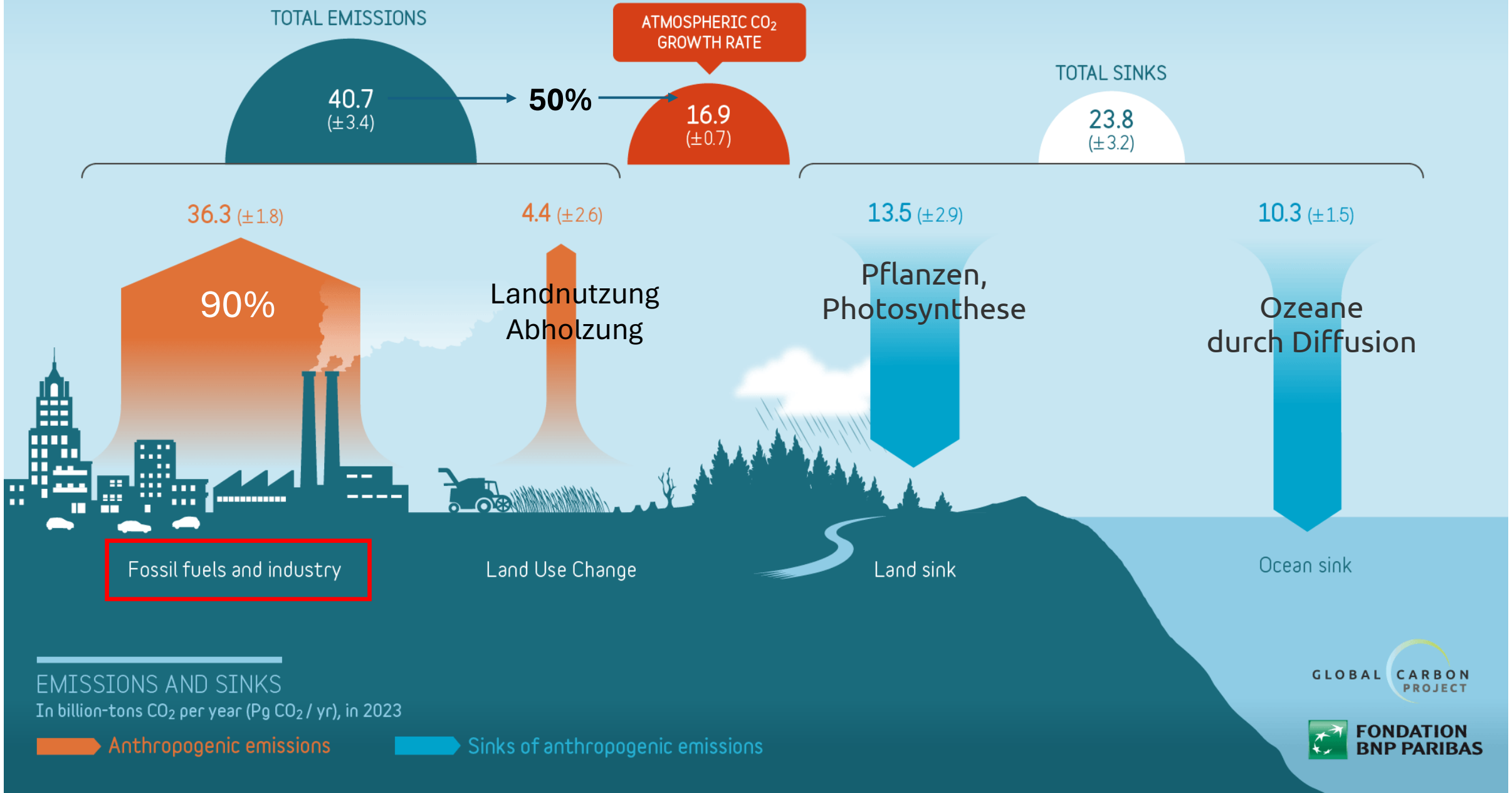
Universität für Bodenkultur Wien

Globaler Kohlenstoff-Zyklus



P. Friedlingstein et al.: Global Carbon Budget 2020

GLOBAL CARBON BUDGET 2023



EMISSIONS AND SINKS

In billion-tons CO_2 per year (Pg CO_2 / yr), in 2023

Anthropogenic emissions

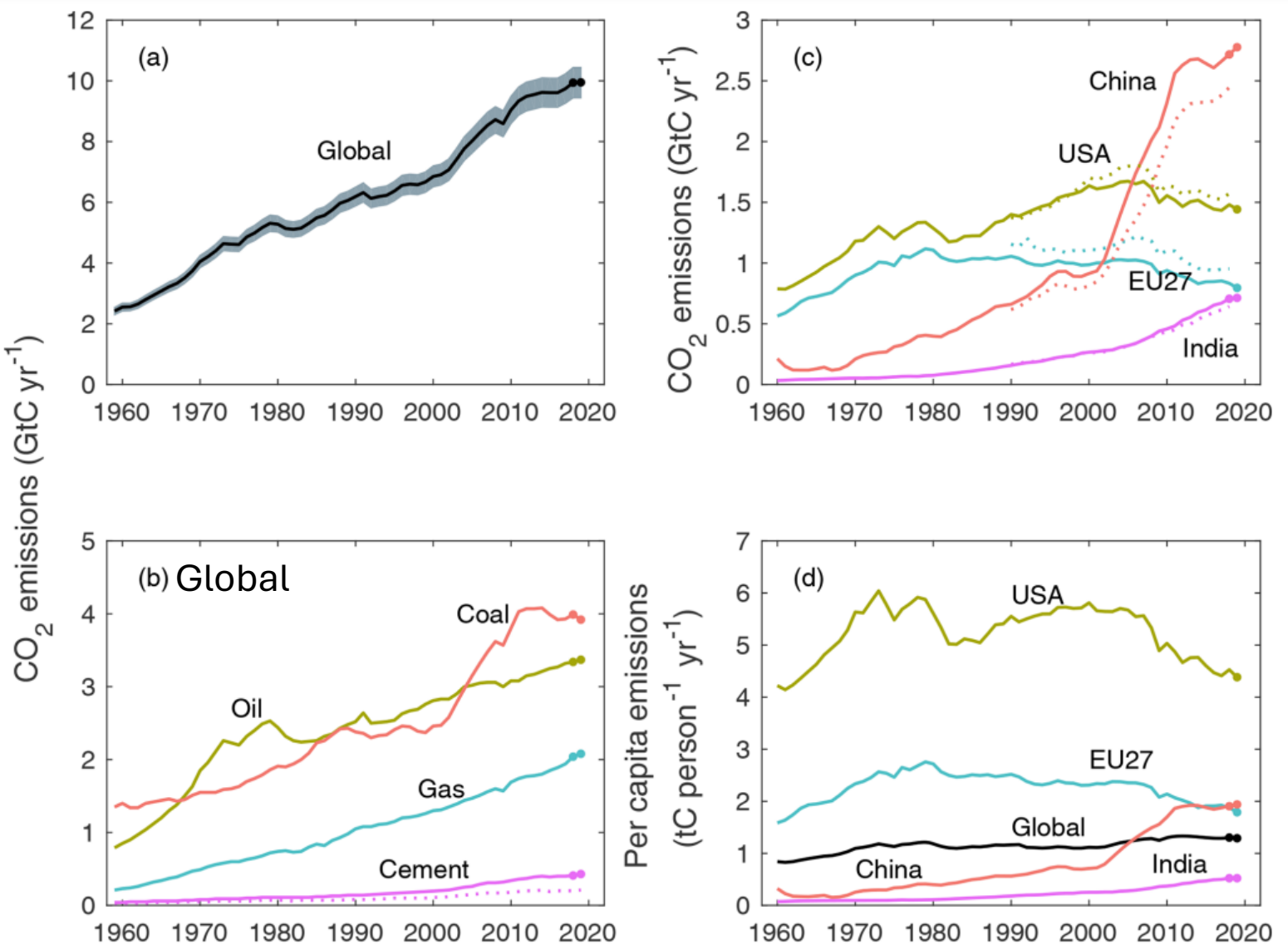
Sinks of anthropogenic emissions

Global Carbon Project

GLOBAL CARBON PROJECT

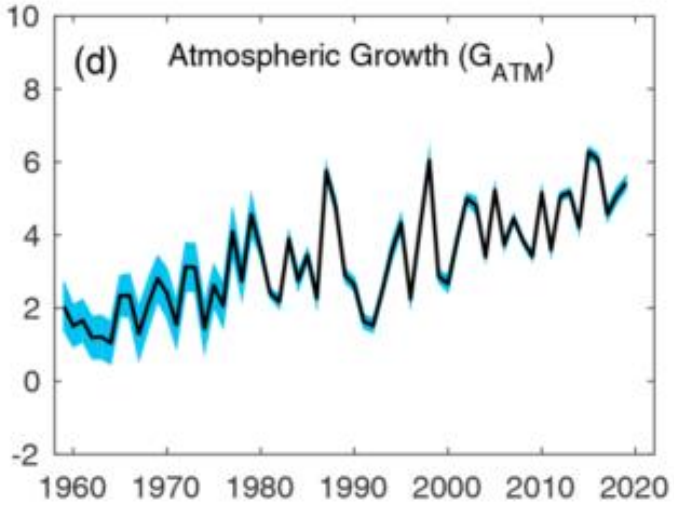
FONDATION BNP PARIBAS

Fossile CO2-Emissionen



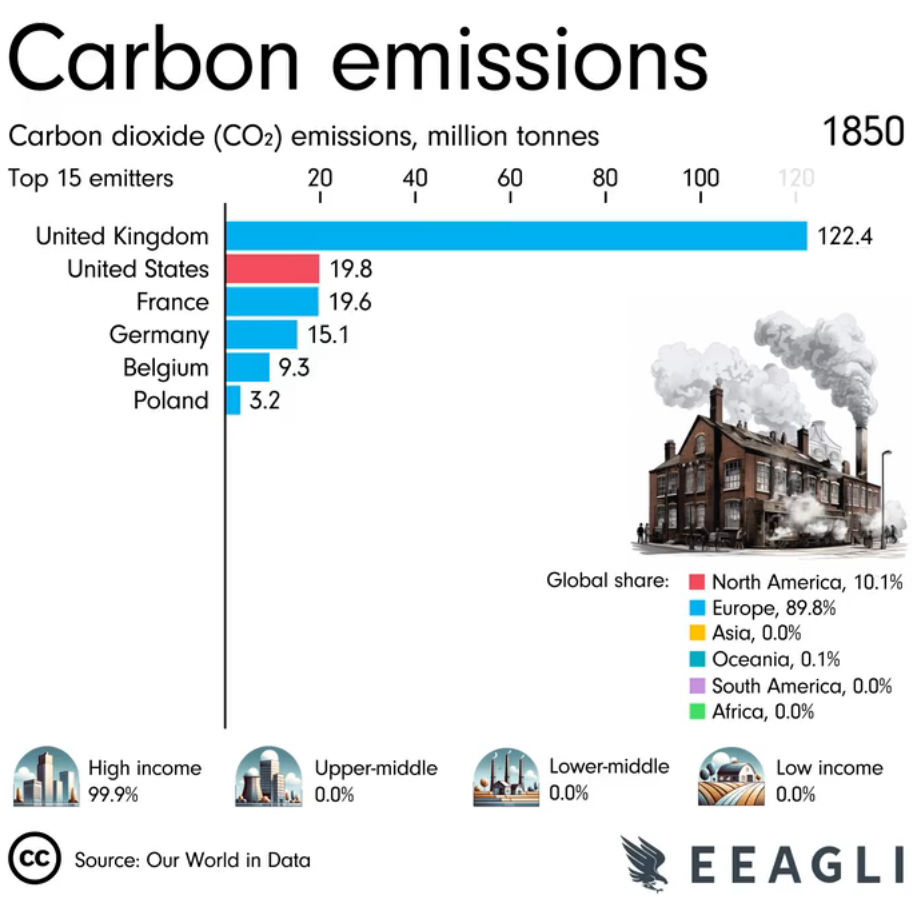
Atmosph. CO2 Wachstum

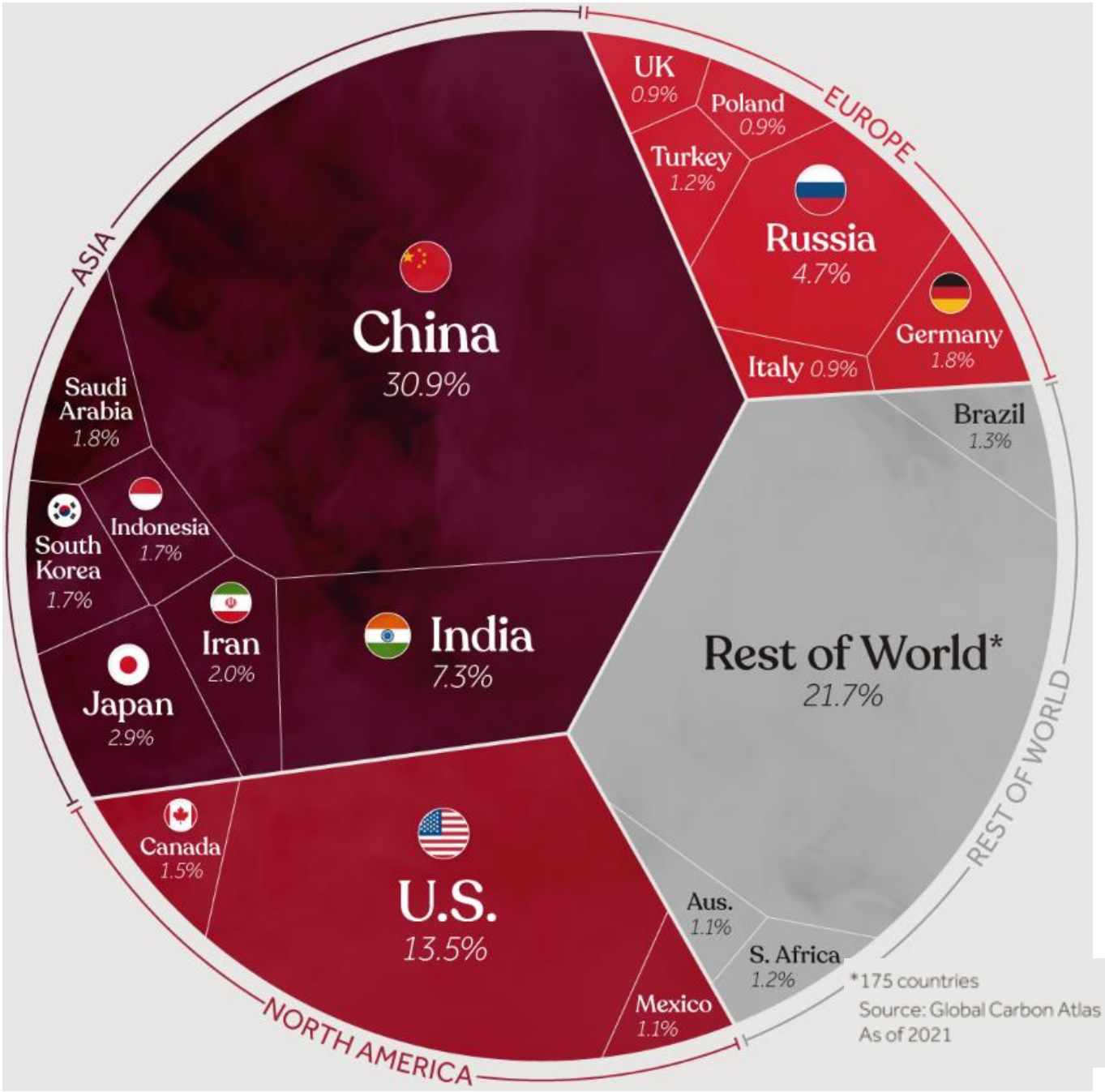
(GtC yr-1) Welt



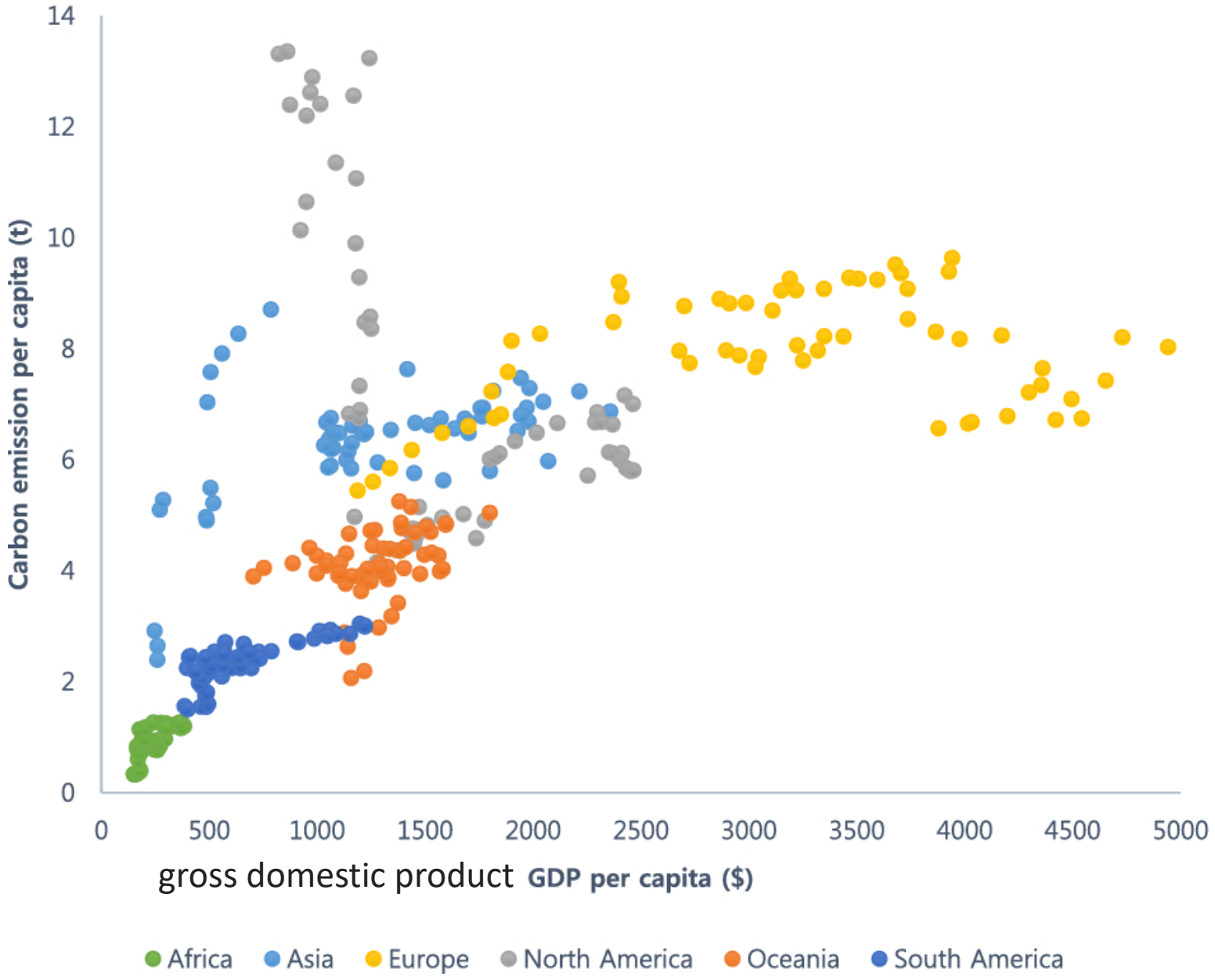
Earth Syst. Sci. Data, 12, 3269–3340, 2020

Kohlenstoffemissionen –Länder





Umwelt Kuznets-Kurve (EKC) - Kontinente



Jung, H., & Song, C. K. (2023). Effects of emission trading scheme (ETS) on change rate of carbon emission. *Scientific Reports*, *13*(1), 912.

Greenhouse gas emissions in the EU by pollutant*

2019

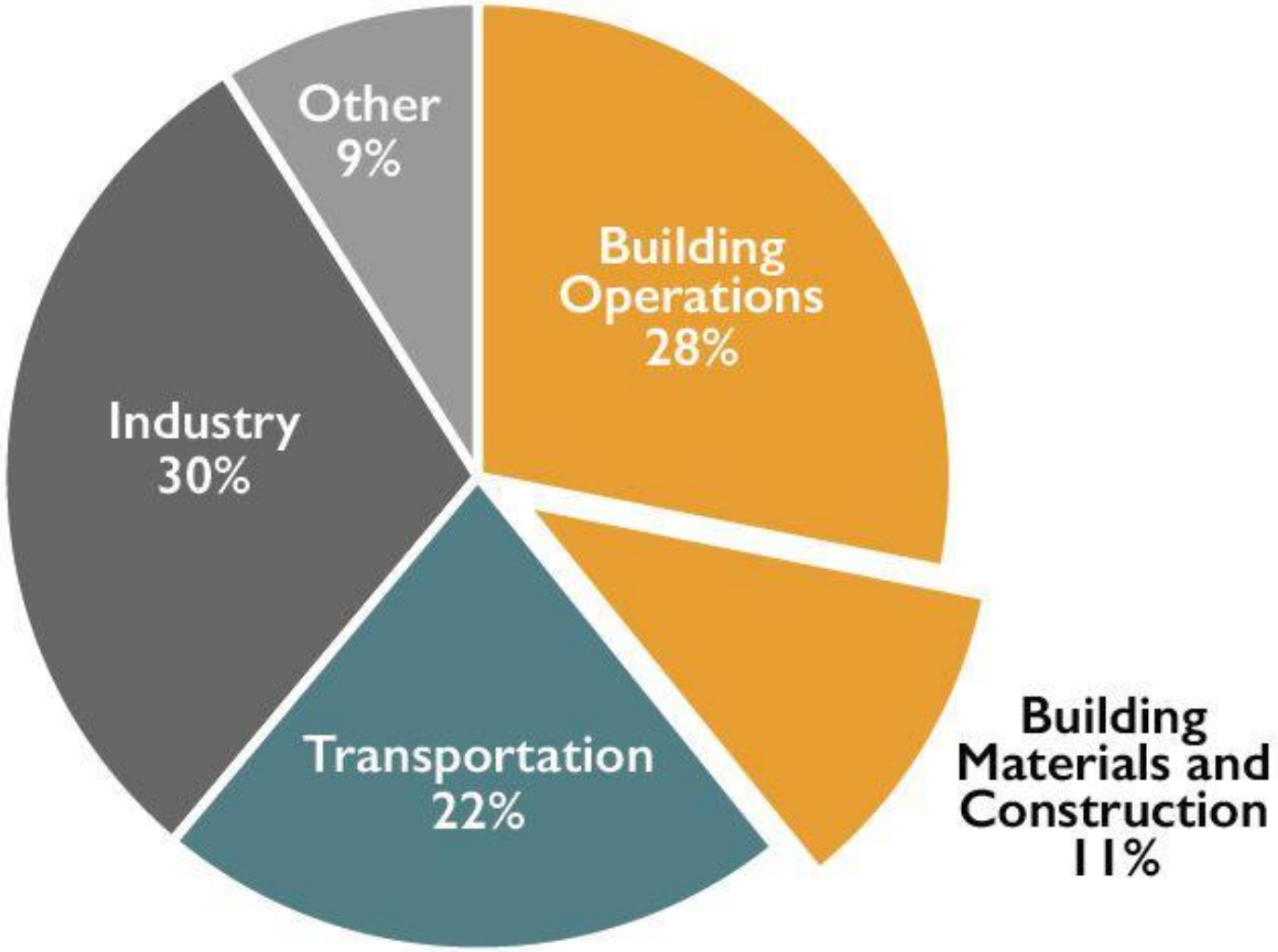
<0.2% of perfluorocarbons (PFCs), unspecified mix of PFCs and HFCs, sulphur hexafluoride (SF6) and nitrogen trifluoride (NF3)

The percentages do not add up to 100% due to rounded figures being used

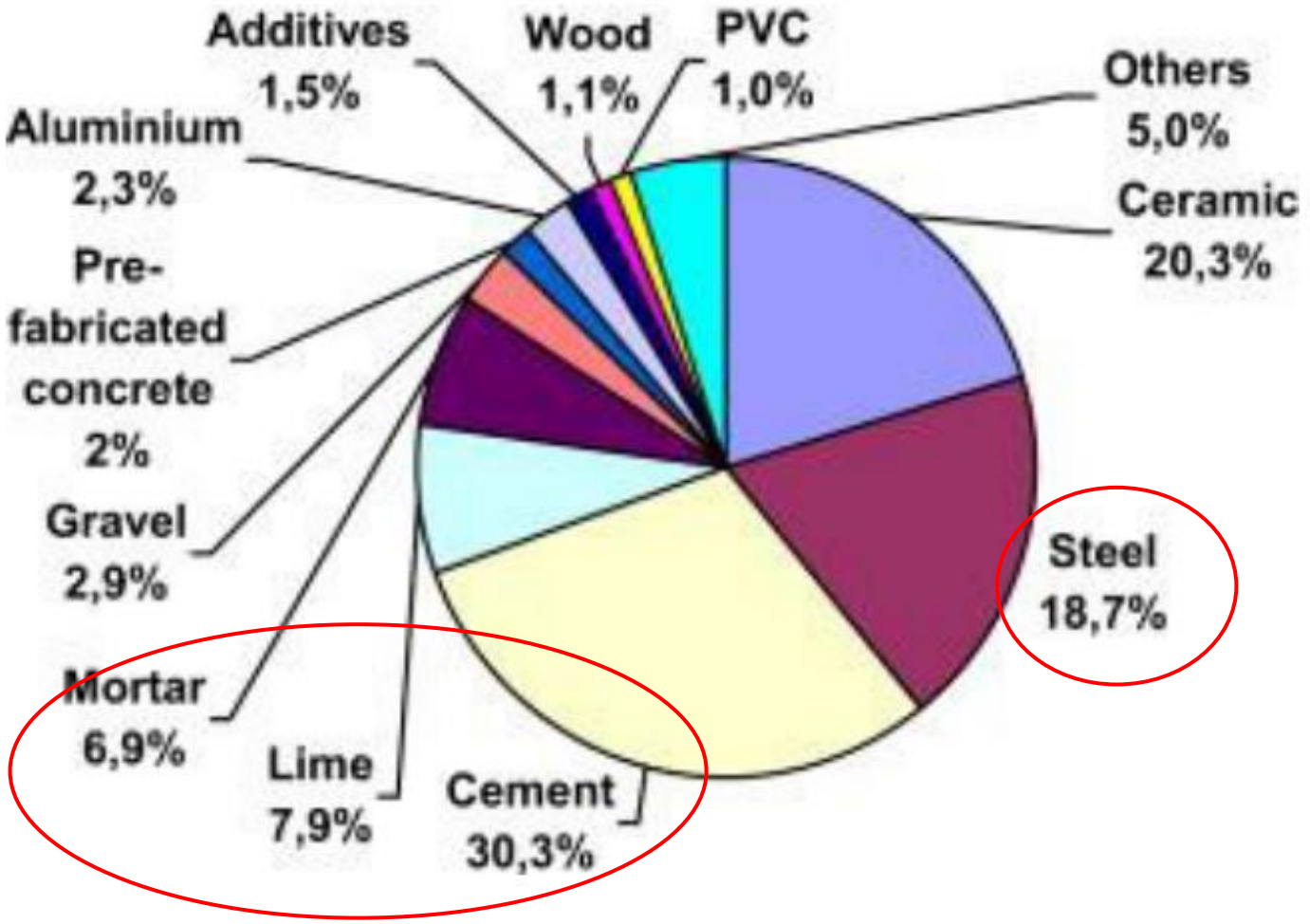
* Total greenhouse gas emissions excluding land use, land-use change and forestry (LULUCF)

Source: European Environment Agency (EEA)

Globale CO2 Emissionen per Sektor



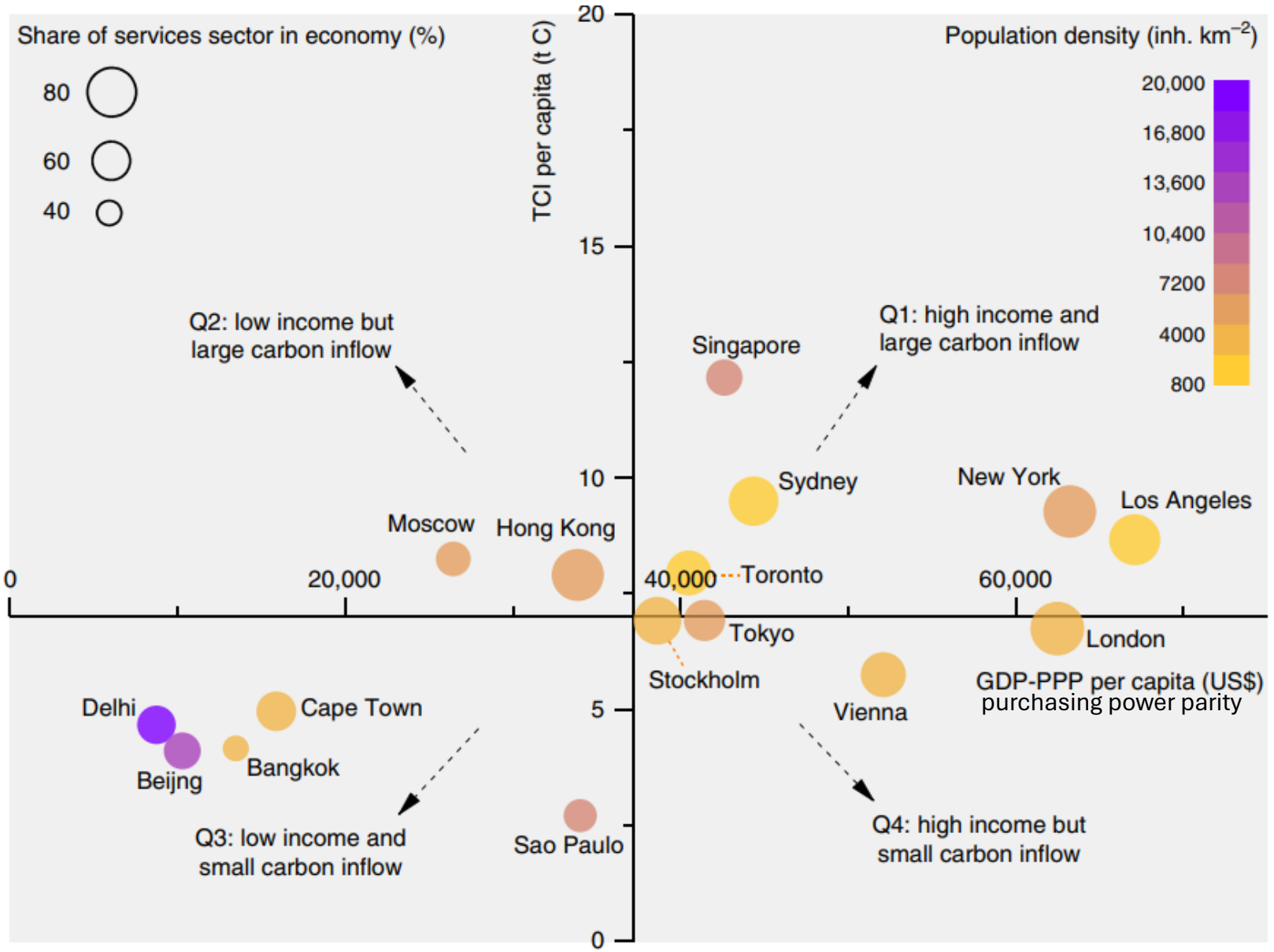
CO2 Emisionen – Beiträge verschiedener Baustoffe



Bribian, et. al., 2011

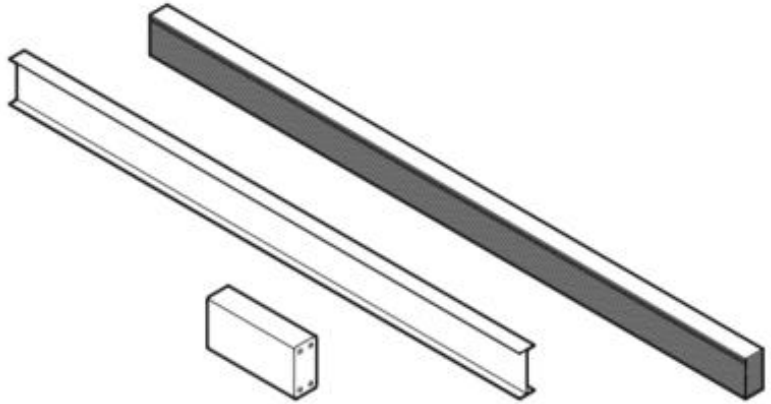
Städte als Kohlenstoffspeicher

TCI: gespeicherter C in Produkten & fossiler, gasförmiger C:
"Carbon Metabolismus einer Stadt"

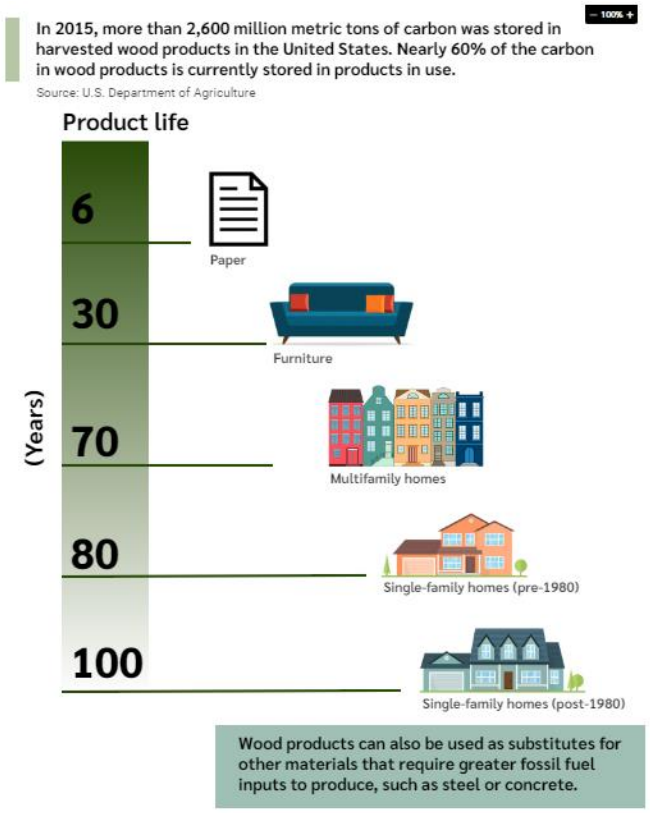


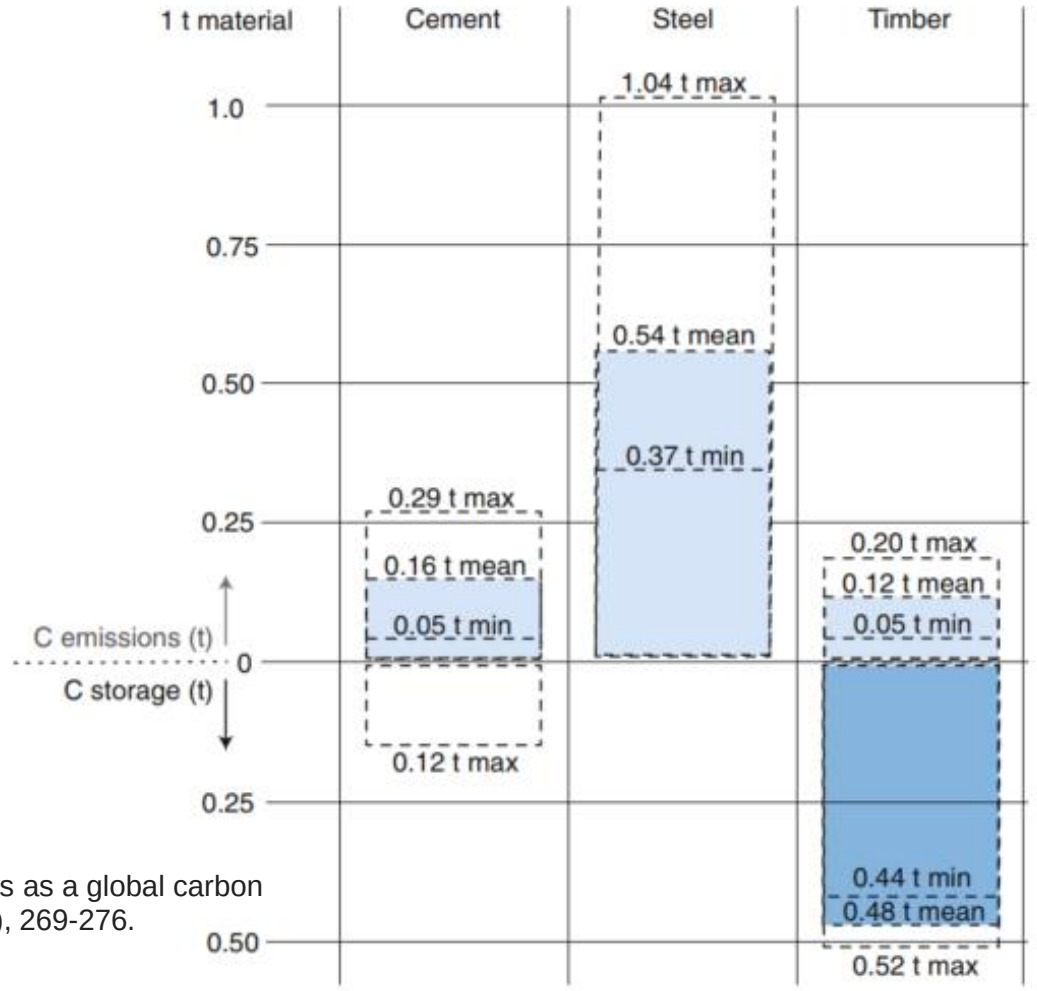
Chen et al. NATURE COMMUNICATIONS | (2020) 11:182 | https://doi.org/10.1038/s41467-019-13757-3 |

Kohlenstoffemissionen – Kohlenstoffspeicherung – Zement vs. Stahl vs. Holz



Lebensdauer von Bau-Materialien





Churkina et al. (2020). Buildings as a global carbon sink. *Nature Sustainability*, *3*(4), 269-276.

Führende EU-Mitgliedstaaten, die Anforderungen an CO2-Neutralität und Kreislaufwirtschaft für Neubauten verbinden

Denmark

- 2020, 90% less energy use in households
- Full decarburization of domestic heating
- 2030, 50% Renewable energy sources
- Clean power (district scale)

Netherlands

- DBED for the new office (>100 m²) and houses
- Life Cycle Assessment (LCA) by qualified experts
- Using green and circular building materials.
- Phasing out natural gas
- Green Public Procurement (quasi mandatory)

Finland

- Low carbon road map for building materials
- 2020, Carbon footprint and emission limits
- 2050, 80% Reduction of emissions
- Minimized use of virgin materials
- Adopting EC's Level(s) method
- Procrurement criteria for low carbon buildings

Sweden

- 2022,Using LCA for all new buildings
- 2045, Eliminate greenhouse gas emissions
- Recycling 70% of construction residues
- Fossil free Sweden initative

France

- 2020, Low carbon Buildings & reduce carbon emissions
- 2050, Carbon-neutral France
- RE2020 threshold of 4 kgCO2 operational emissions equivalent/m2 for new residential buildings: E+C
- Phasing out natural gas
- Dynamic LCA calculation method + threshold for embodied carbon emission of 100 kg of CO2 per m2

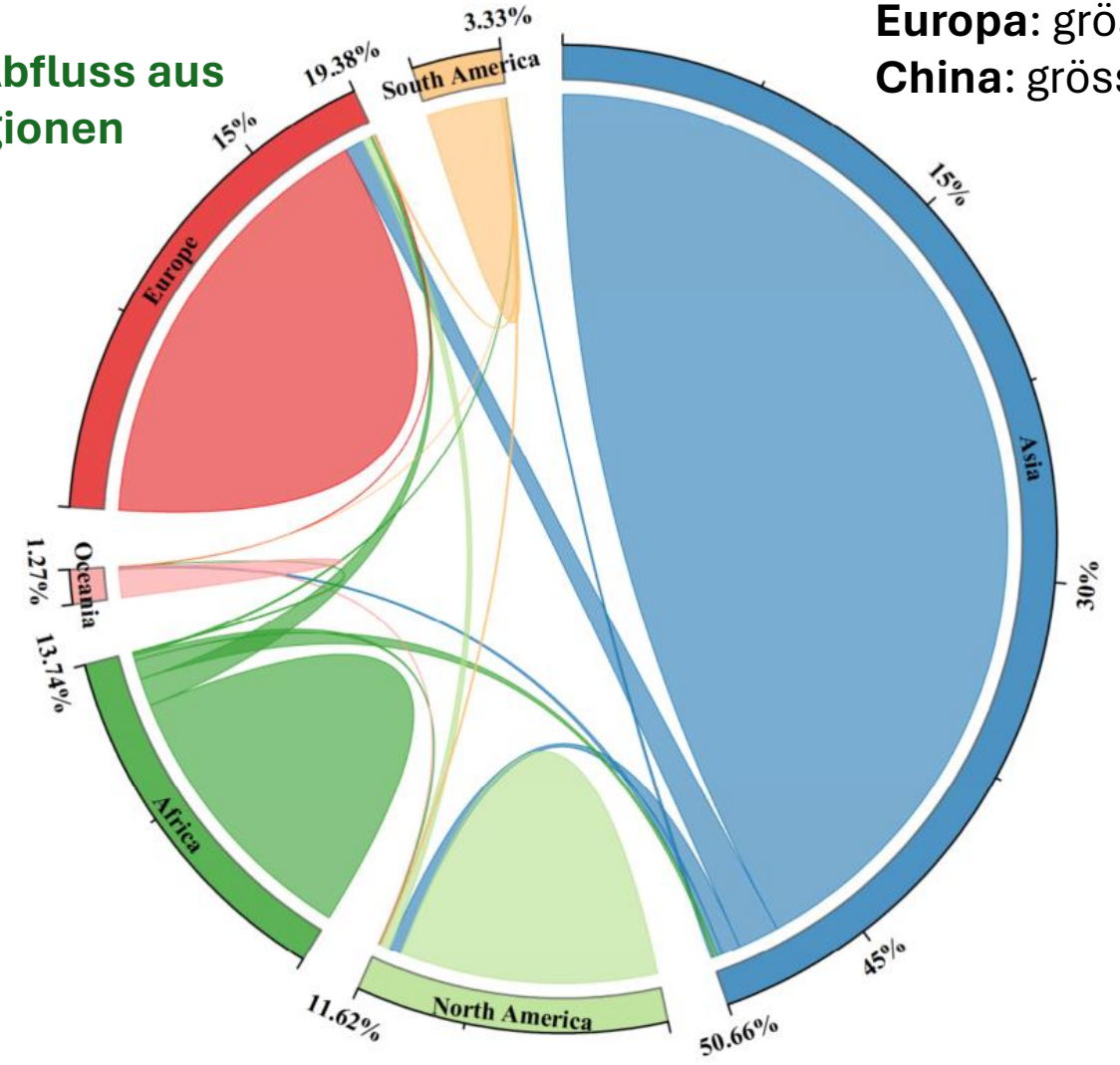
S Attia et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 855 012023

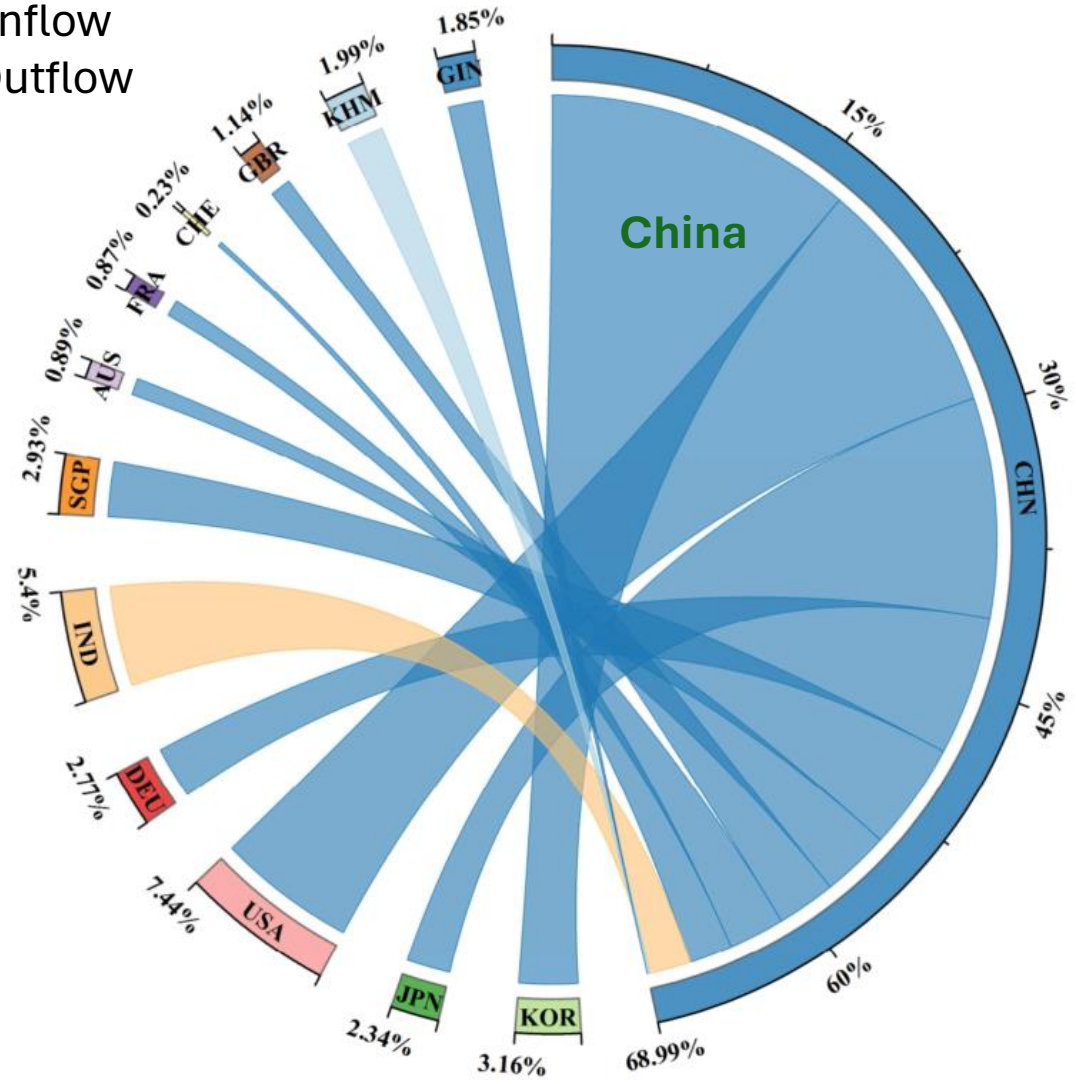
Kohlenstofftransfer durch Handel

Kohlenstofftransfer durch China

Europa: grösster C-Inflow
China: grösster C- Outflow

C-Abfluss aus Regionen

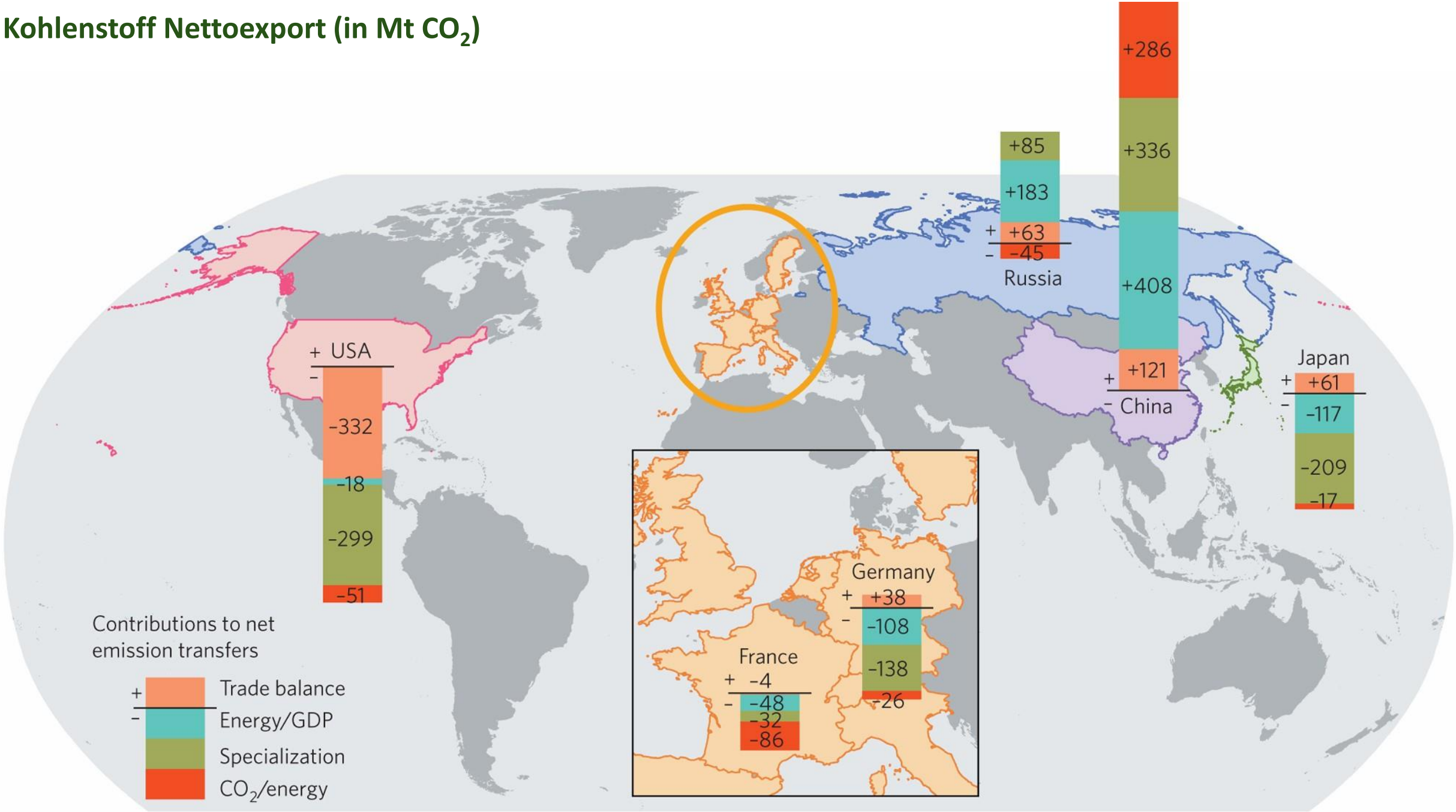




„*Reiche Länder*“: Import von **geringwertigen, carbon-intensiven** Produkten
„*Ärmere Länder*“: Import von **hochwertigen, carbon-armen** Produkten

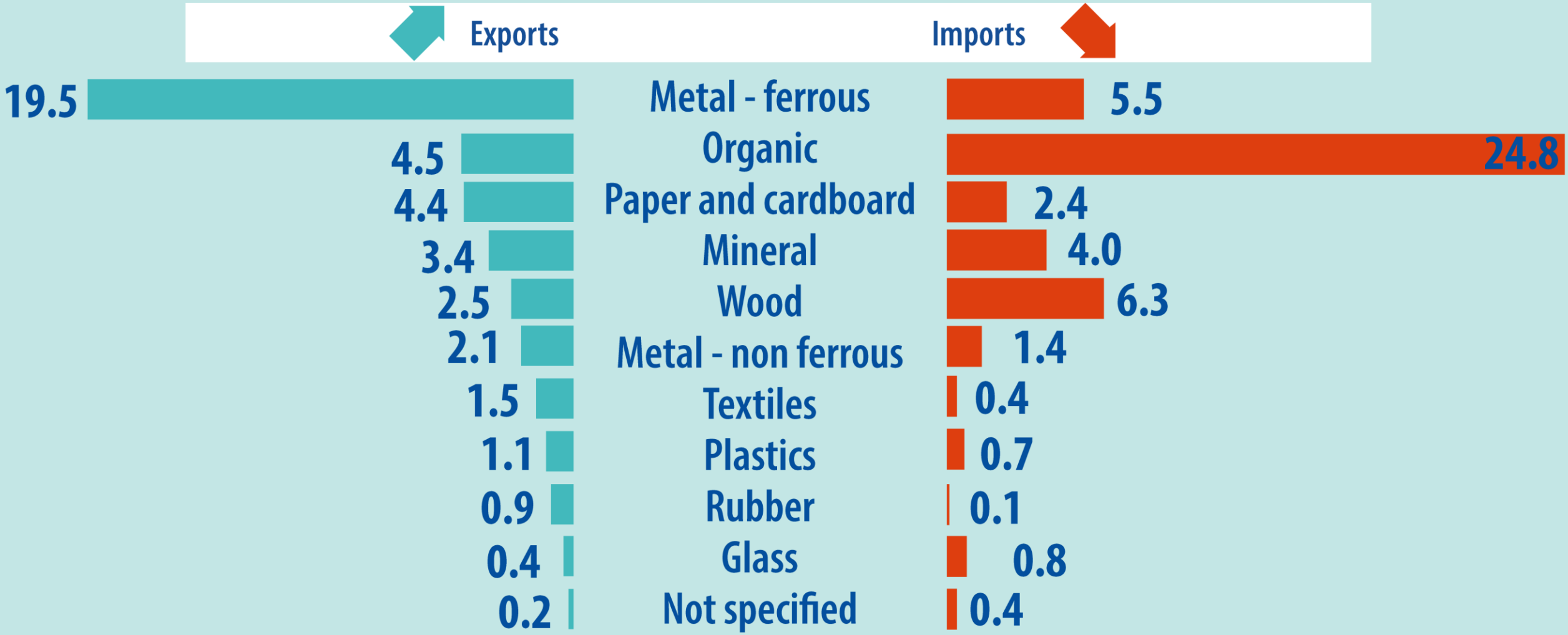
Zhou et al. Int. J. Environ. Res. Public Health **2022**, *19*, 14605

Kohlenstoff Nettoexport (in Mt CO_2)

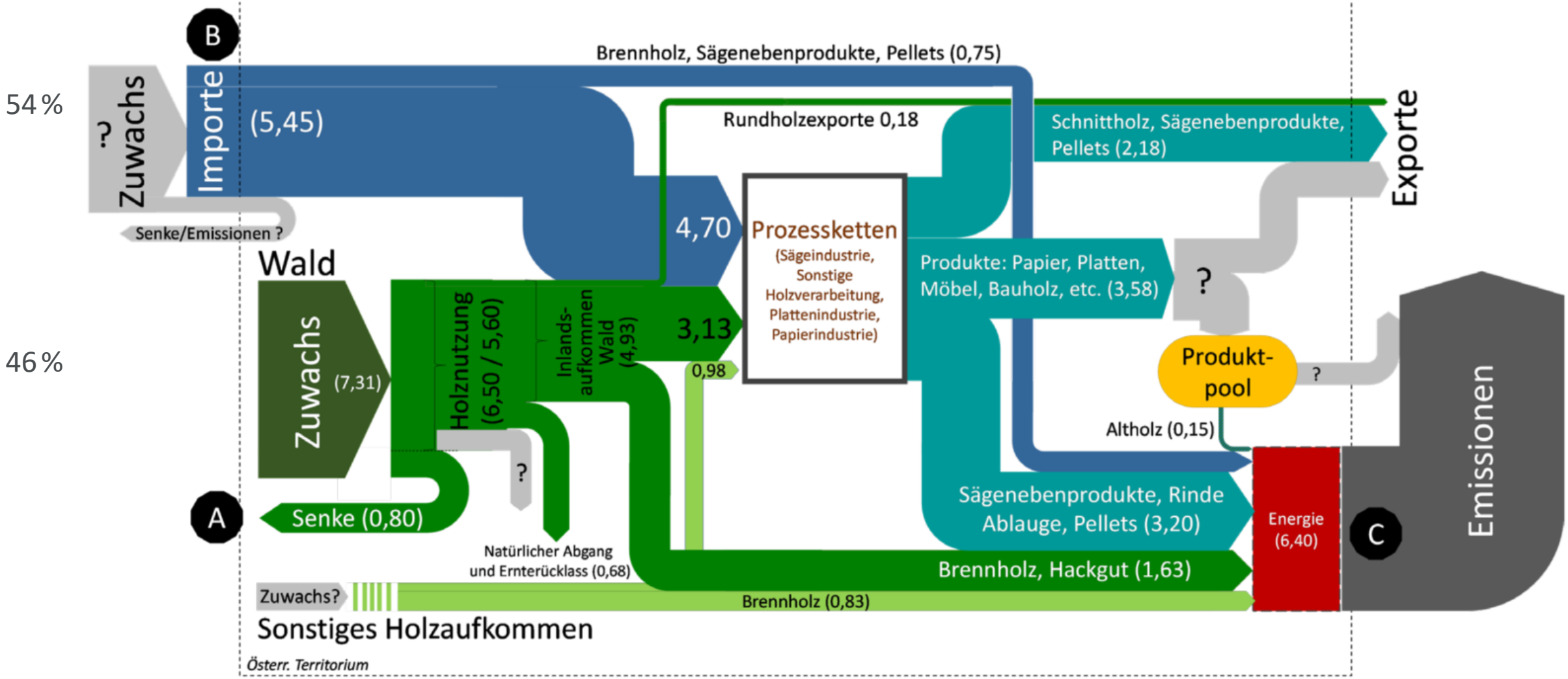


Zhou et al. *Int. J. Environ. Res. Public Health* **2022**, *19*, 14605

Extra-EU trade in recyclable raw materials by category (million tonnes, 2021)



Categories sorted by largest exports to smallest.



Holz-Kohlenstoffflüsse Österreichs 2020 in Mio tC/Jahr.

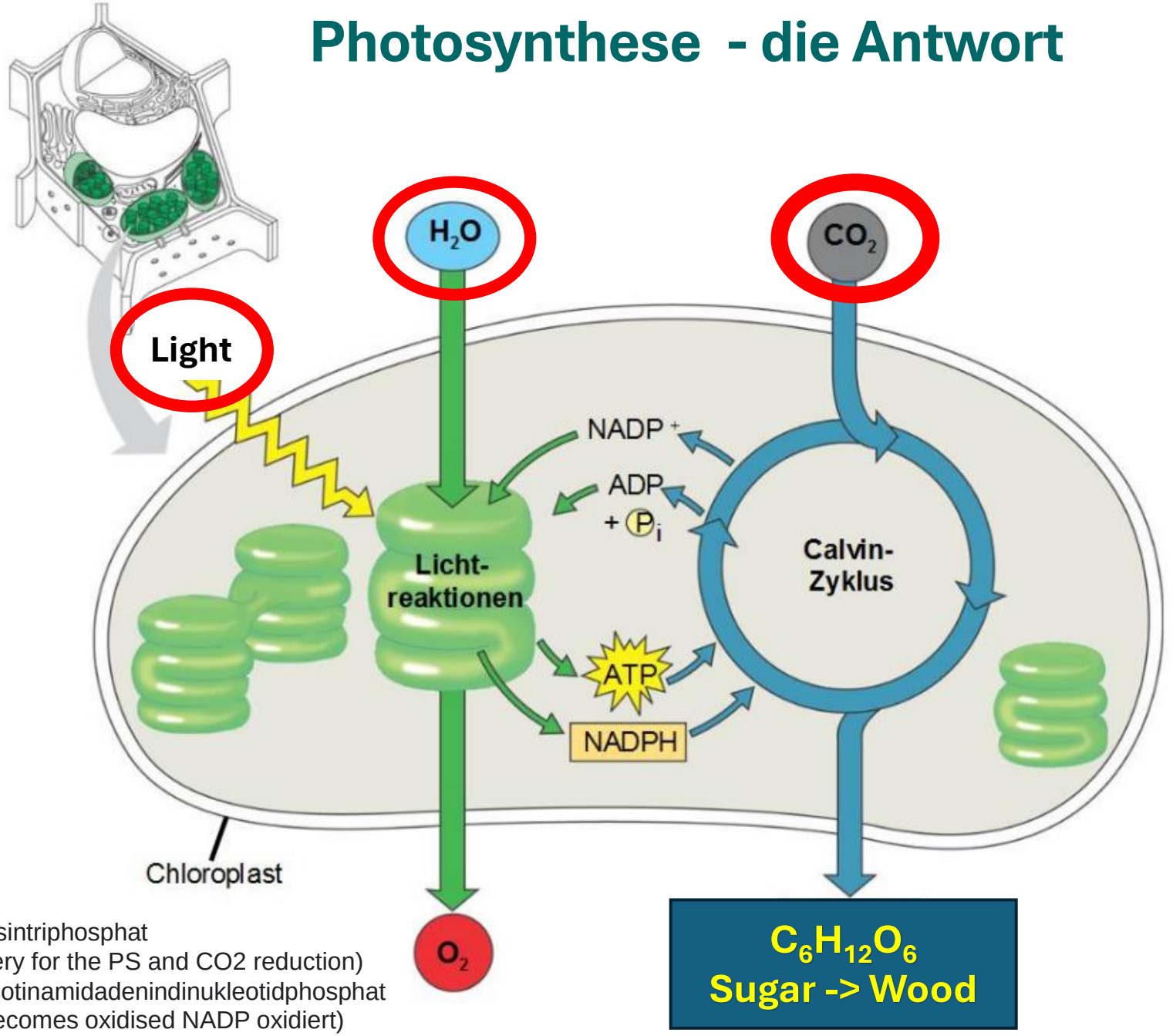
Aus: BFW. Österreichische Waldinventur. https://www.waldinventur.at/#/ (2022); Strimitzer et al. 2020: Holzströme Österreichs 2020. BM Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, Österreichische Energieagentur, LKÖ, 2022

Mehr Holzverwendung durch Innovation

Woher kommt die Masse eines Baumes?

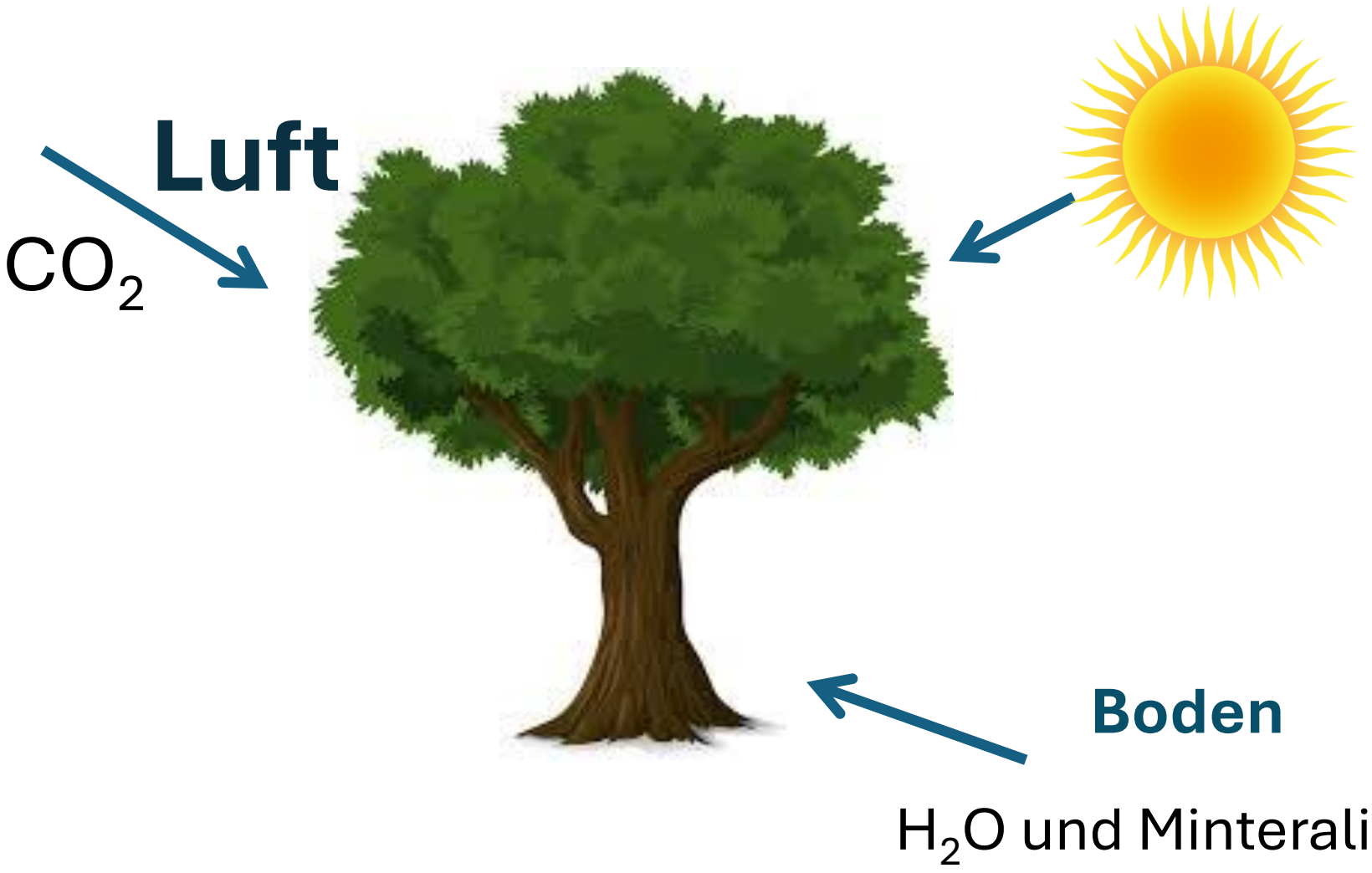

LAZER

Photosynthese - die Antwort



ATP = Adenosintriphosphat
(delivers engery for the PS and CO2 reduction)
NADPH = Nicotinamidadenindinukleotidphosphat
(H donator, becomes oxidised NADP oxidiert)

Holz besteht zu 93% aus Luft (CO_2)

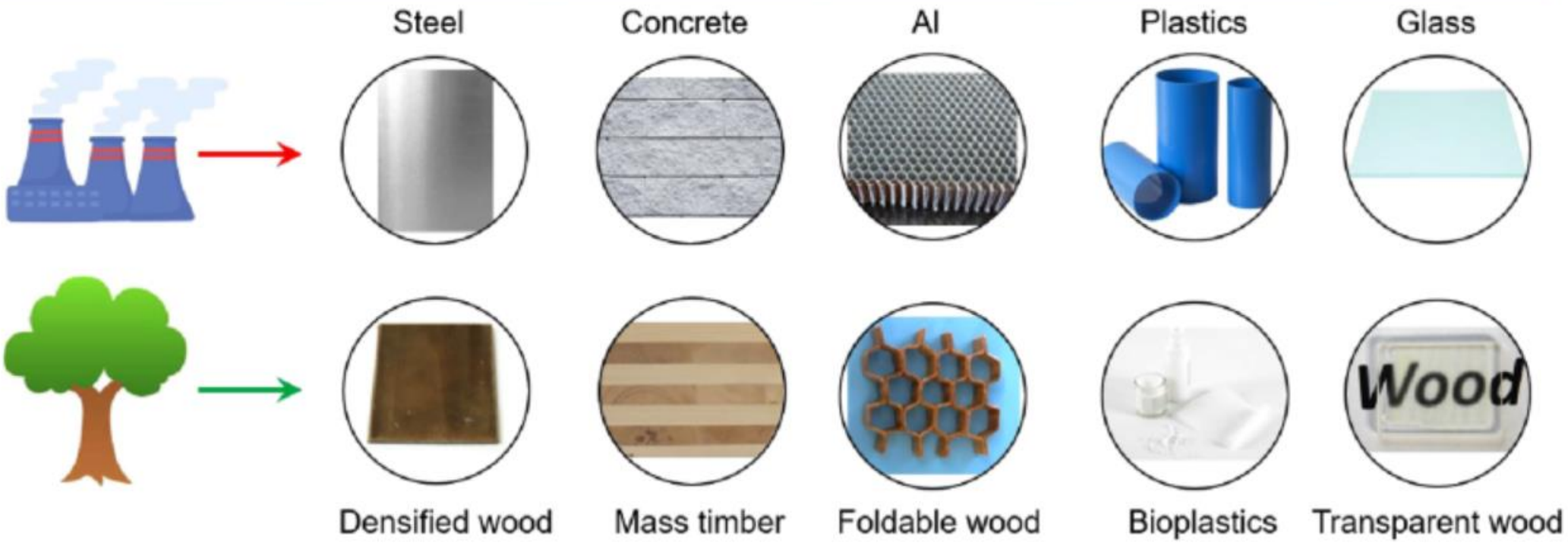


Holz ist ein “Luftmaterial”

Holz - Das bist Du!!!

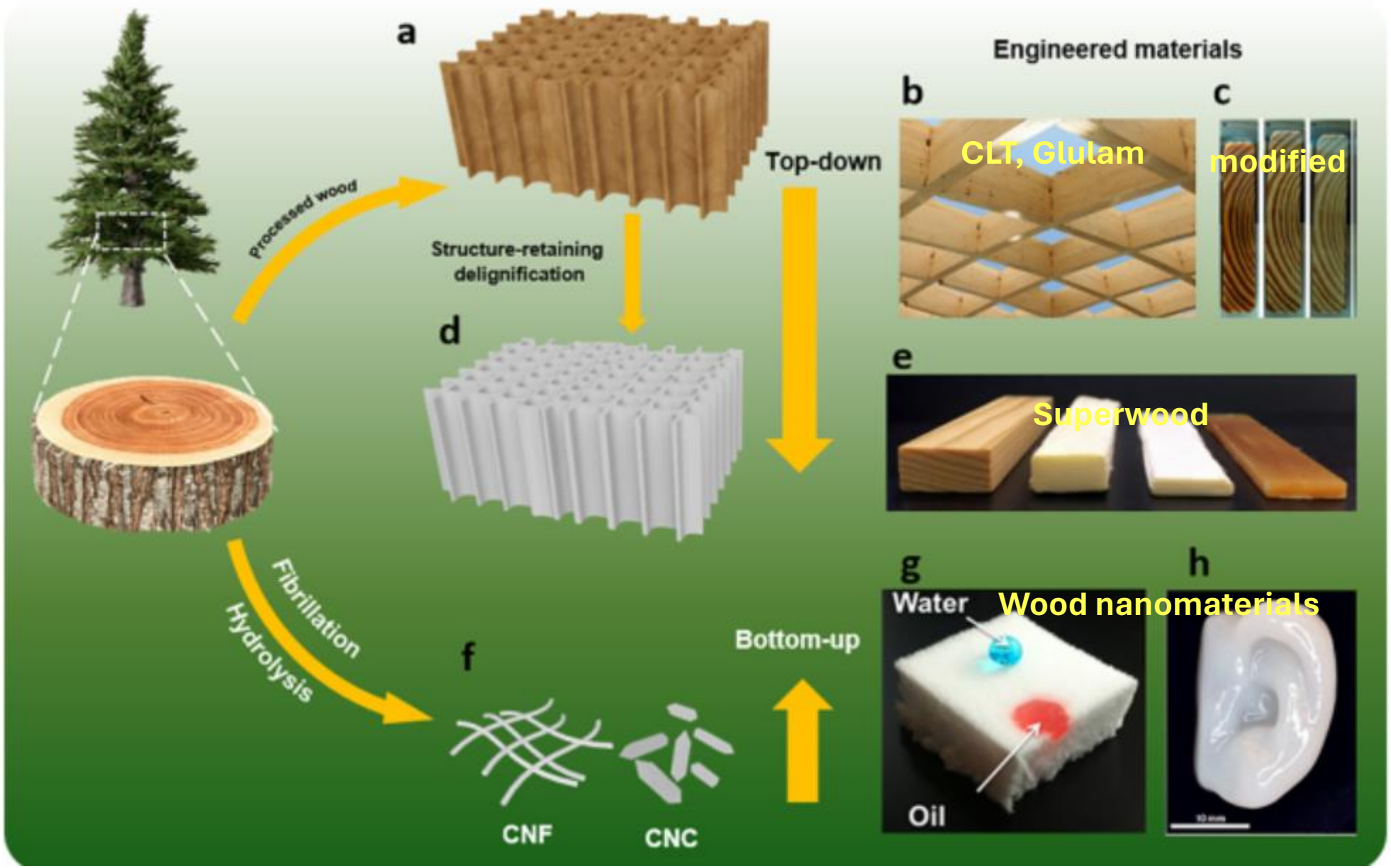
CO2 Emisssionen im Gebäudesektor – Innovative Alternativen

	Steel industry	Cement industry	Al industry	Plastics industry	Glass industry
Global CO_2 emissions/year (gigaton)	3.7	2.5	1.1	0.85	0.086



Ding et al. 2023, Chem. Rev.

Viele Möglichkeiten für High-Tech Anwendungen



Schubert et al. (2023): Chem. Rev. 123

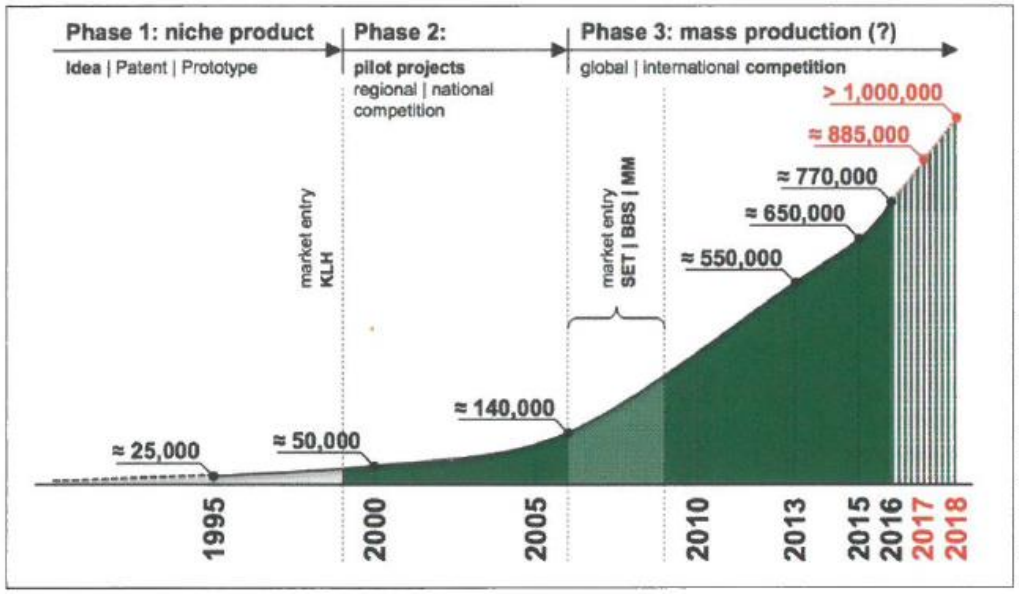
Engineered Wood Products: Furnierschichtholz (LVA)

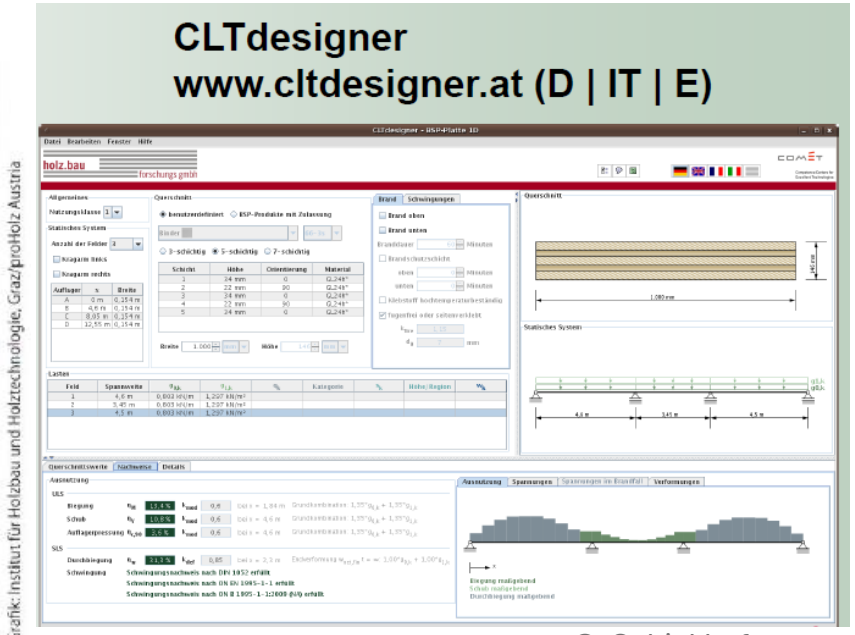
Production:
Global 3 mio m³
Europe 0,5 mîo m³ - Softwood and Beech
Flanges for I- joists, beams, studs, purlins, Glulam

Softwood/Kerto/Metsä Wood

Baubuche/Beech - Pollmeier

Engineered Wood Products: Kreuzlagenholz (CLT)

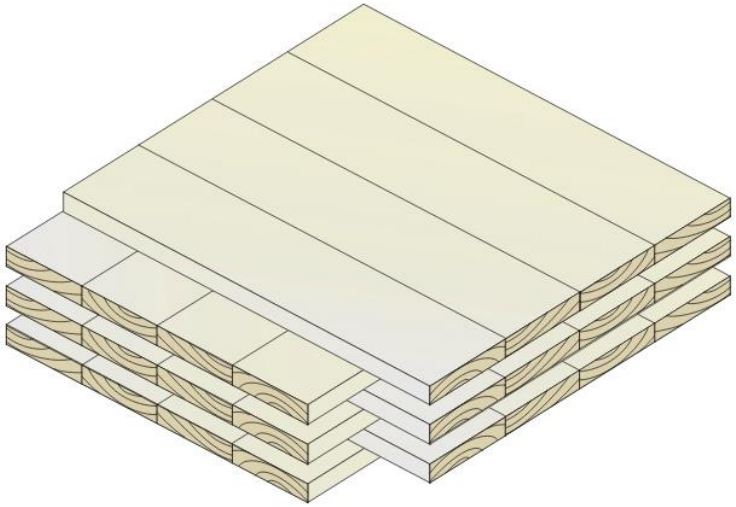


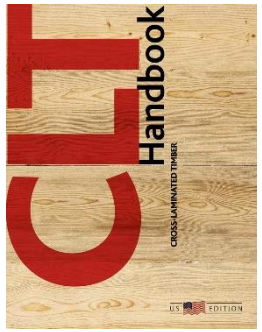


G. Schickhofer

holz.bau forschungs gmbh

TU Graz
Graz University of Technology





Engineered Wood Products: Kreuzlagenholz (CLT)

High-rise mass-timber solutions

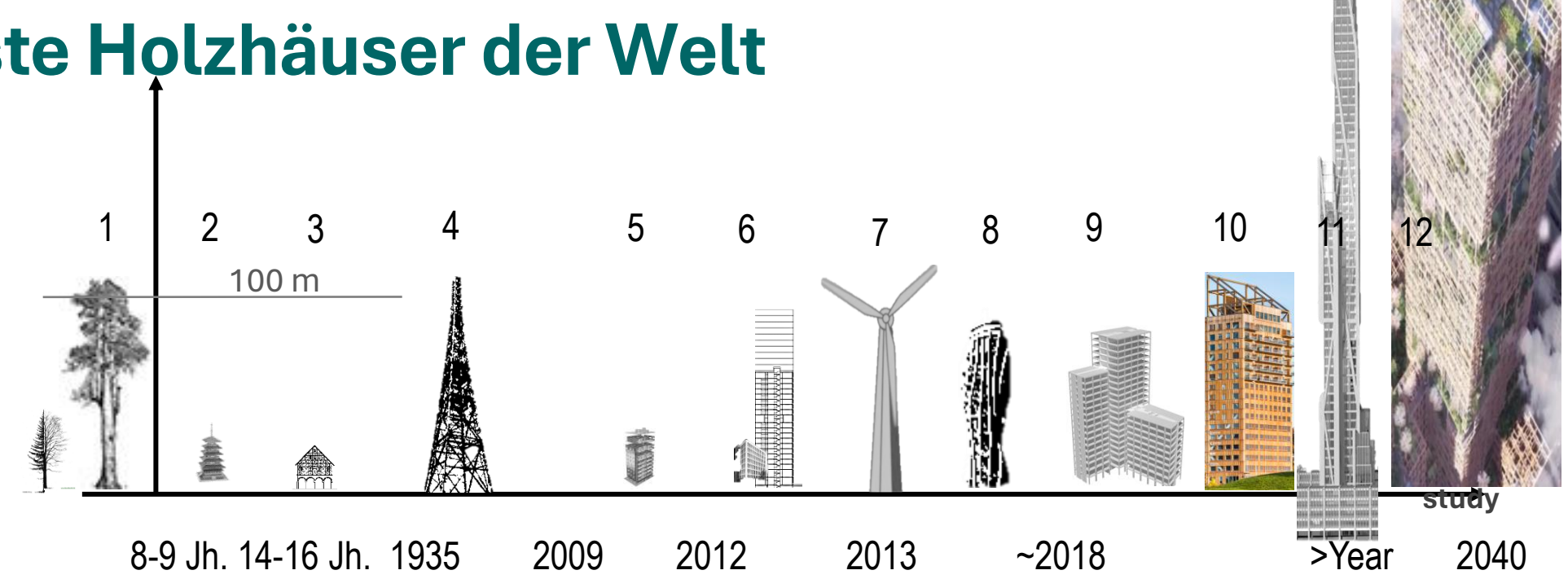
Architects and Designer such as: M. Green /CDN (TED),
H. Kaufmann (AT/DE), T. Kaden (DE/AT) etc.

Urban solutions in wood

HOHO – Seestadt, Wien

75% HOLZ – 84 METER – **24 STOCKWERKE** – 800 HOLZ-STÜTZEN
16.000M^2 CROSS LAMINATED TIMBER

Höchste Holzhäuser der Welt

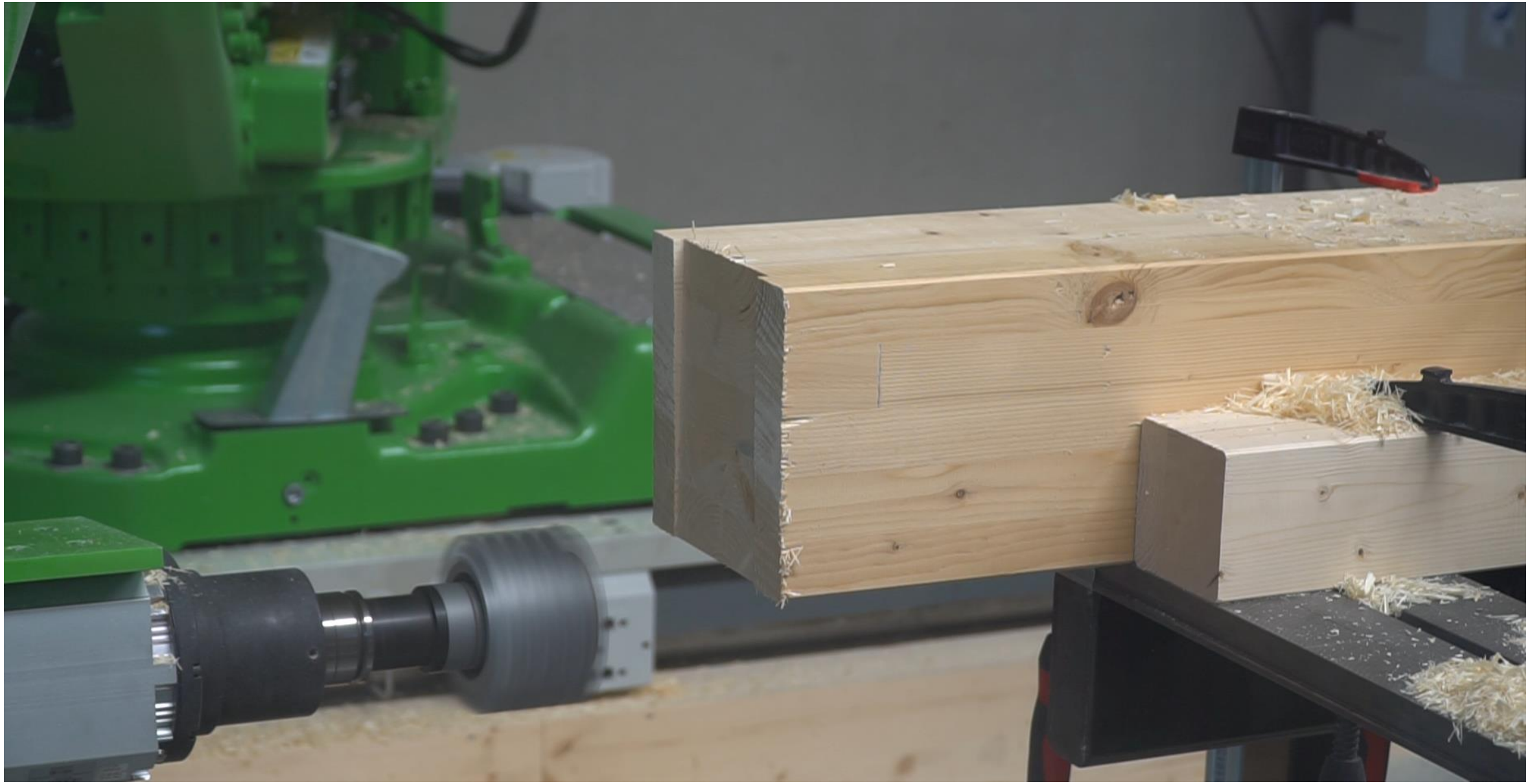


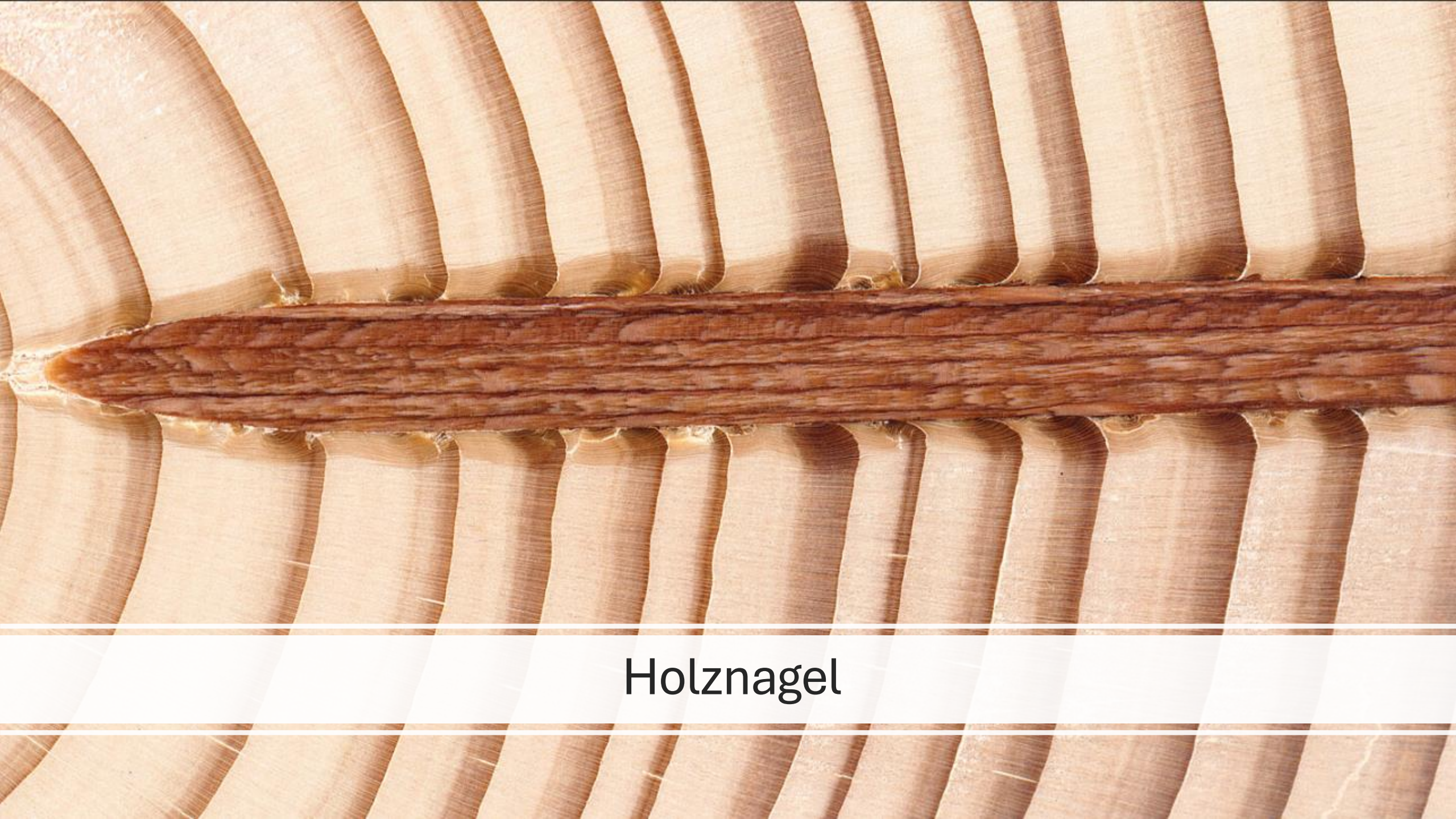
1 Trees and super large “Hyperion”, 115,85 m, USA
2 Five-story pagoda, 32 m, Nara – JPN
3 Fachwerk-House, 26m, DE
4 Sendeturm/transmitter tower Gleiwitz, 118m, PL
5 Murray Grove, 27m, London - GB (start of bigger construction with CLT)
6 CLT One, 20 m, Dornbirn – AT (pilot building – concept for 100m)
7 Windmill wooden tower, 100 m, Hannover - DE
8 Observation Tower Pyramidenkogel, 100 m, Keutschach – AT (highest wood observation tower)
9 **HOHO Wien, 84m, Wien Aspern – AT** (currently highest wooden building construction)
10 Mjøsa Tower, Lake Mjøsa, 85,4m, Norway
11 “Oakwood Tower”- Case Study, **300m, London**, UK PLP Architecture and Cambridge University’s Department of Architecture's,
12 Concept/vision 2041 – 350 m in Japan

Pre-requisites for timber construcion.

- Engineers for timber design
- Timber design codes, based on scientific research
- Materials and components such as GLULAM & CLT (competitive)
- Architects for construction design
- Constructors/investors etc.

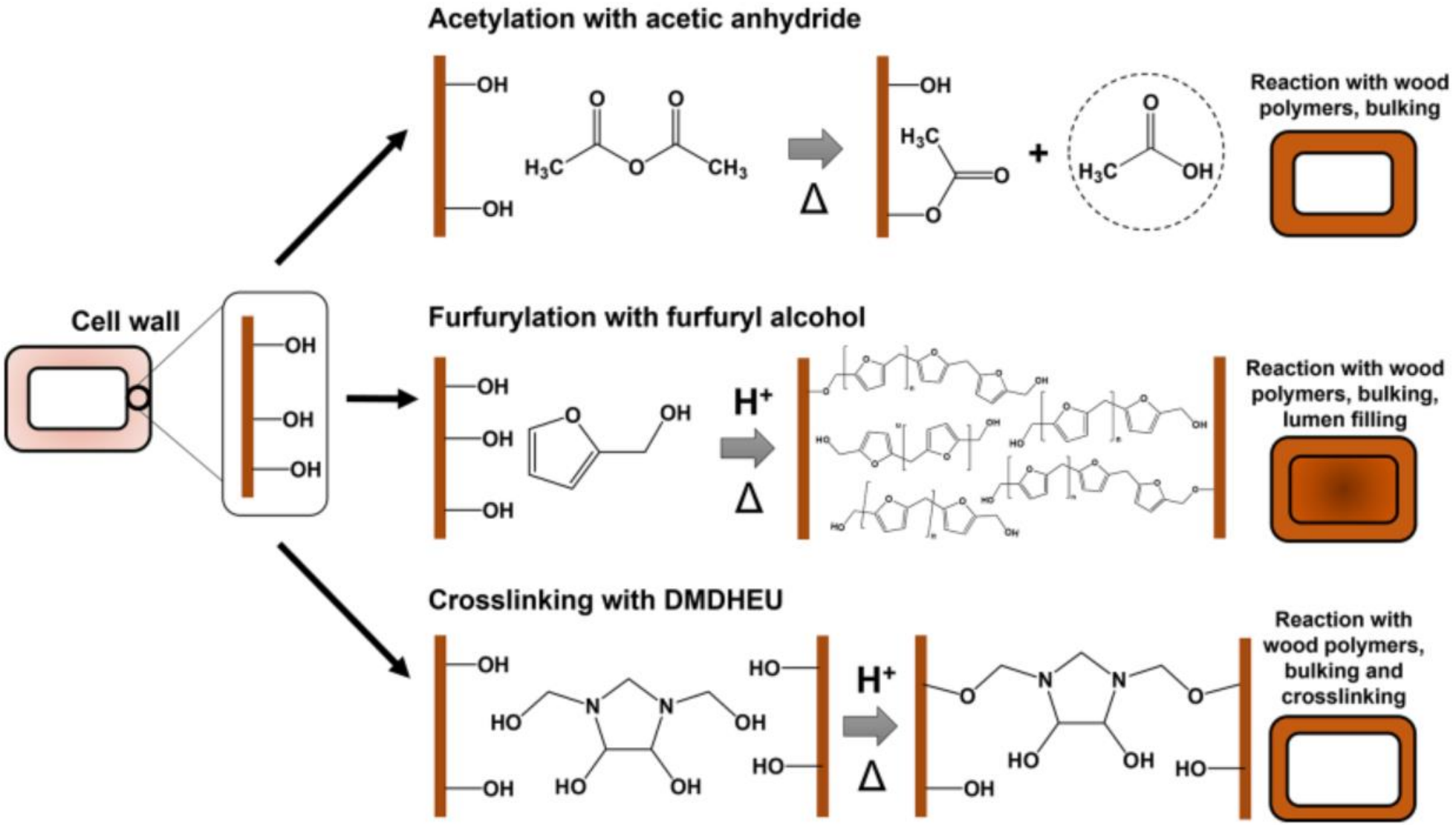
Innovative Holztechnologien



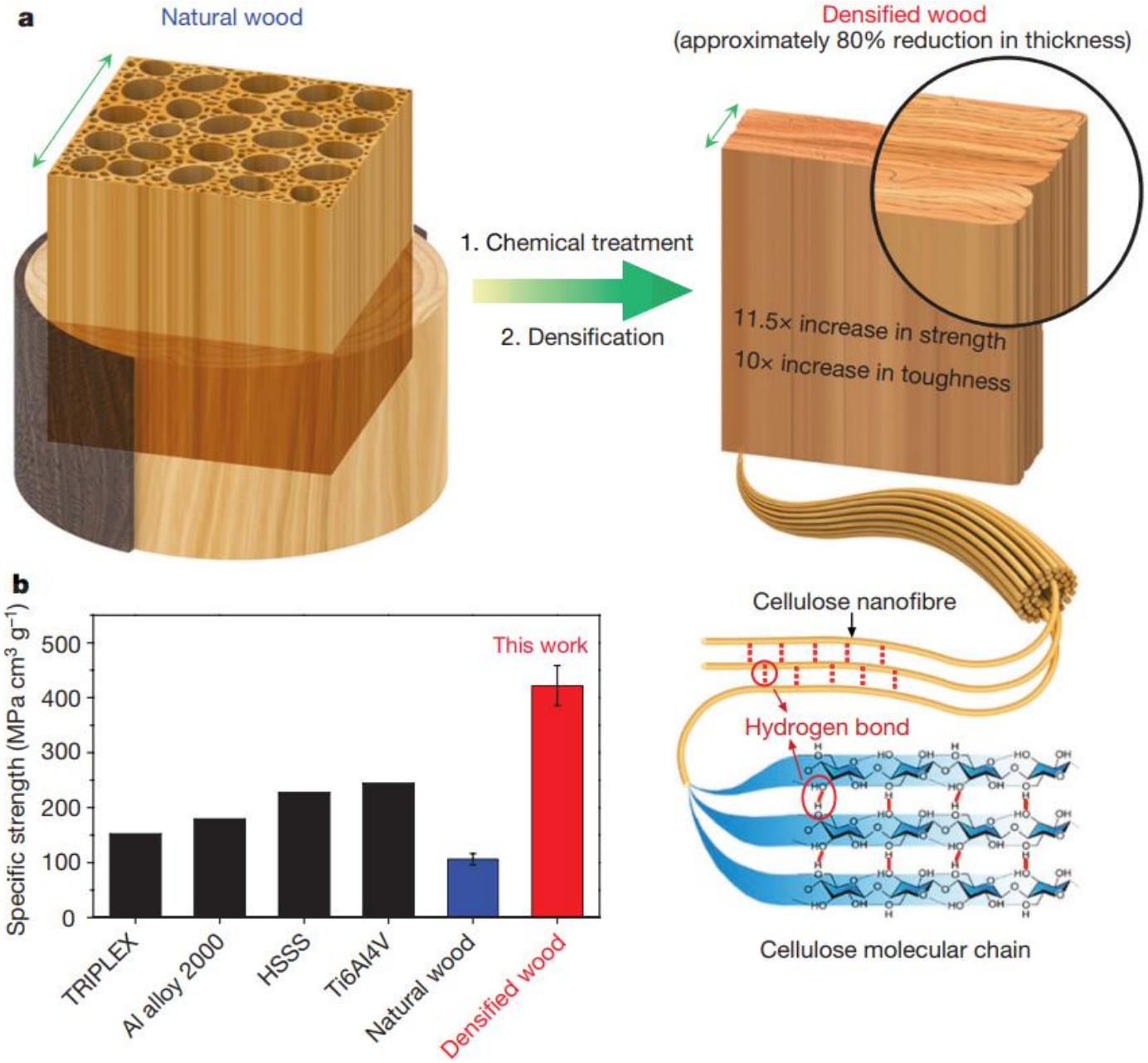


Holznagel

Holzmodifikation - Prinzipien

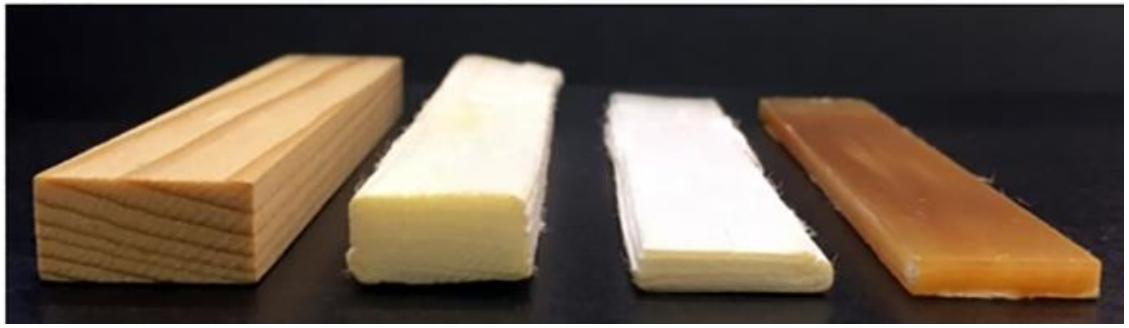


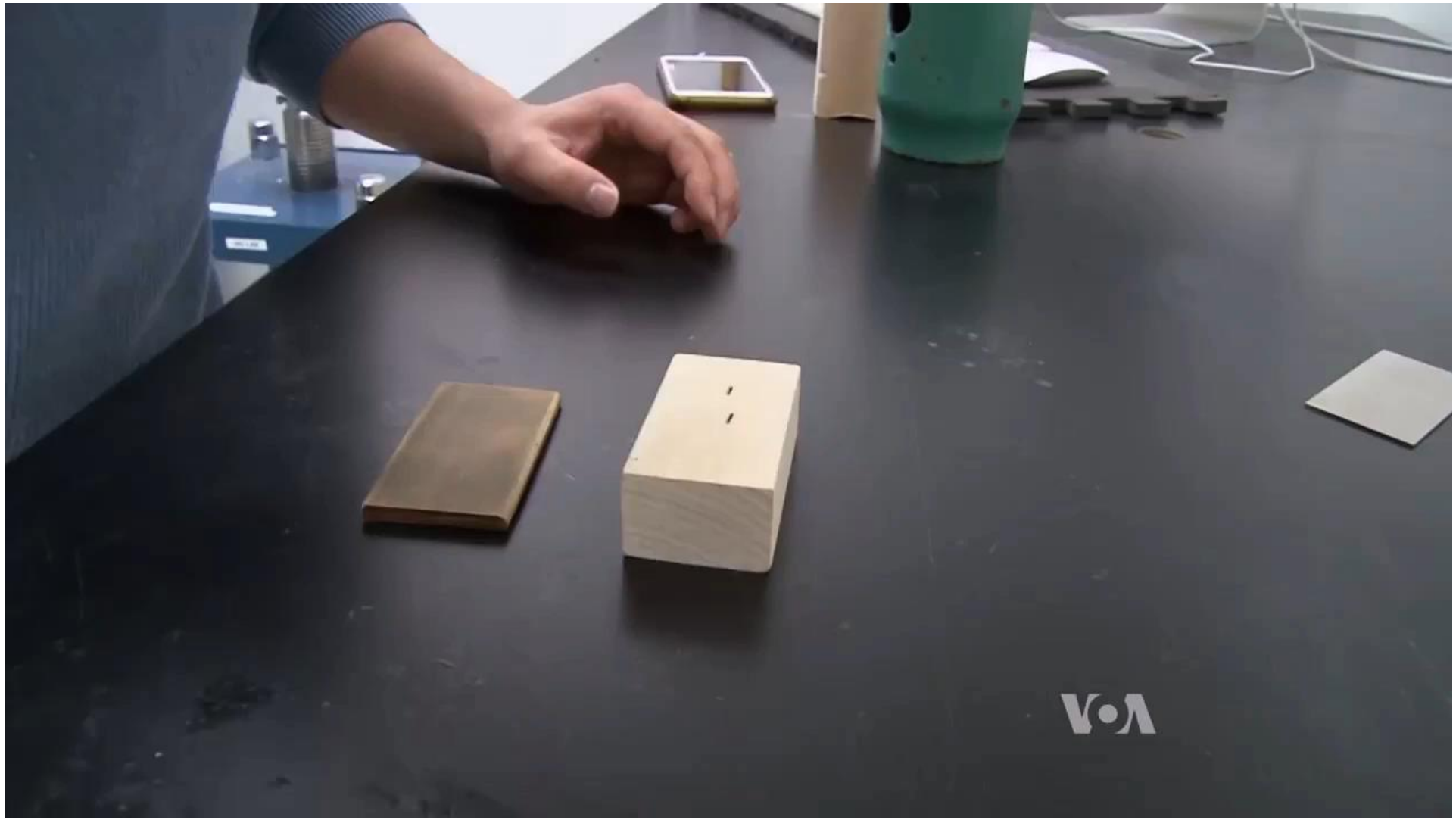
Superwood



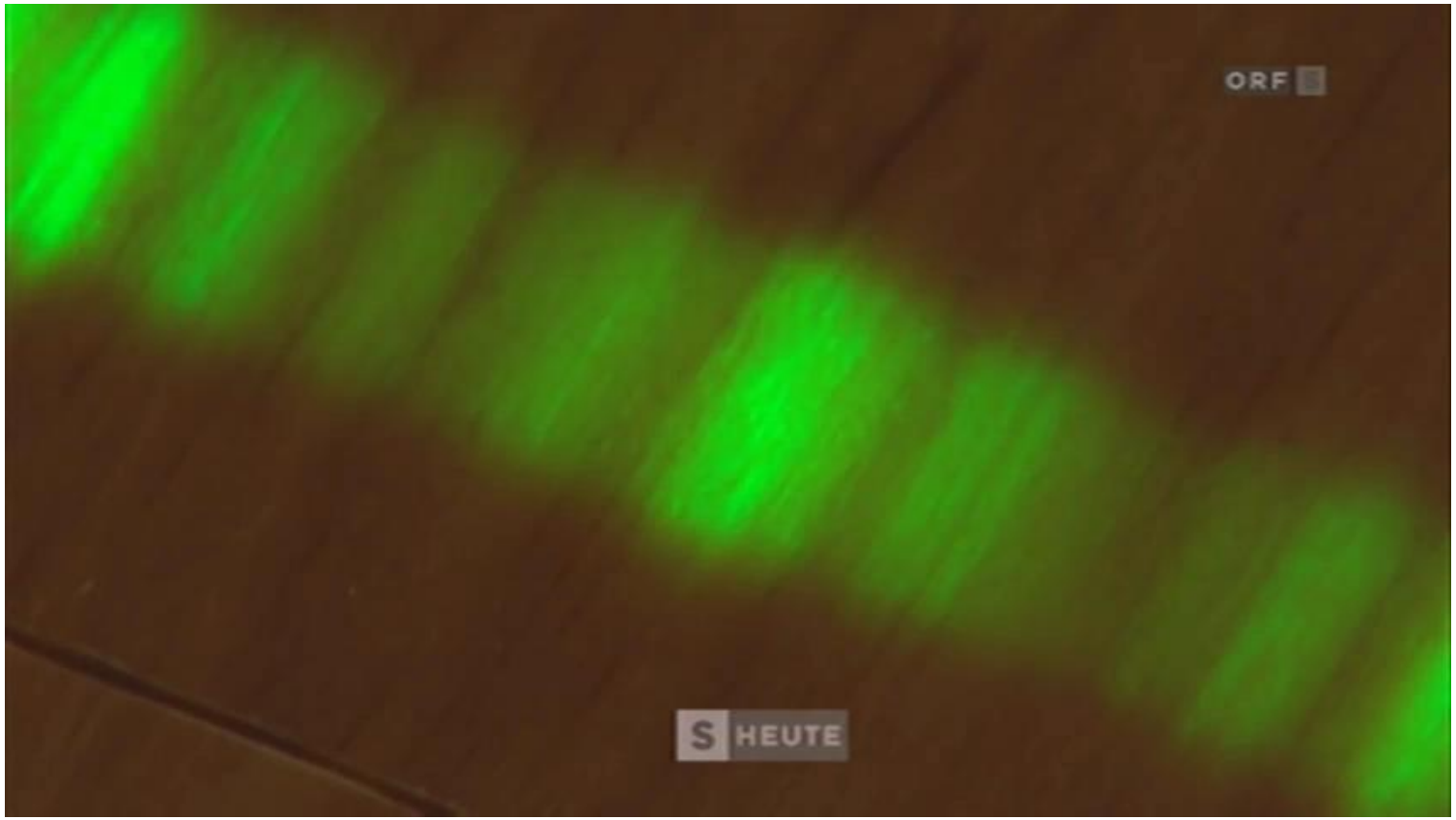
Song et. al. 2018. Nature 554

Superwood



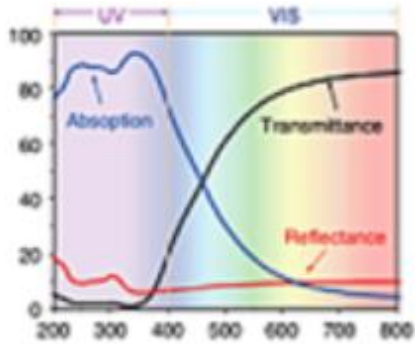


Transparentes Holz

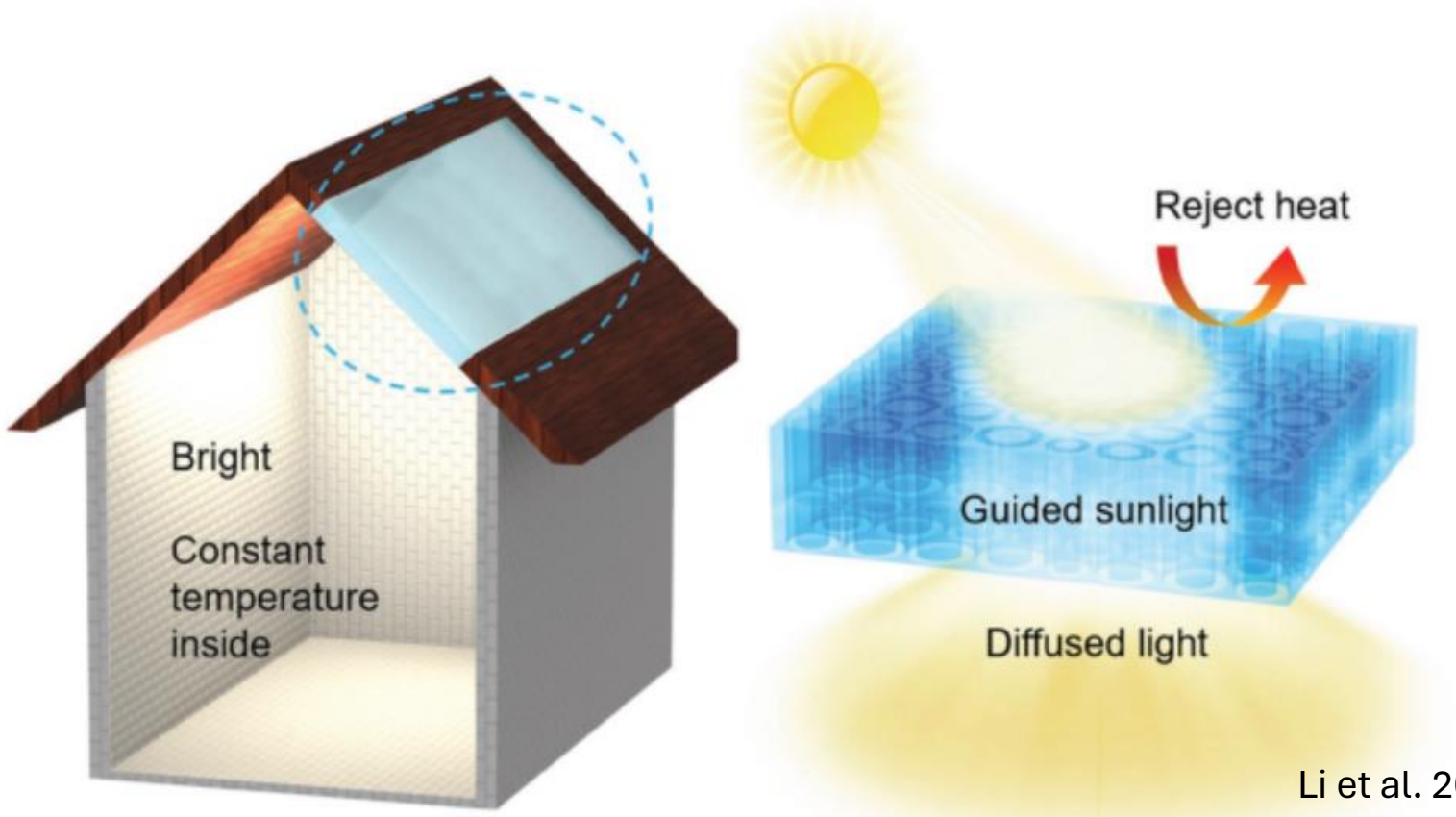


Delignification / Bleaching

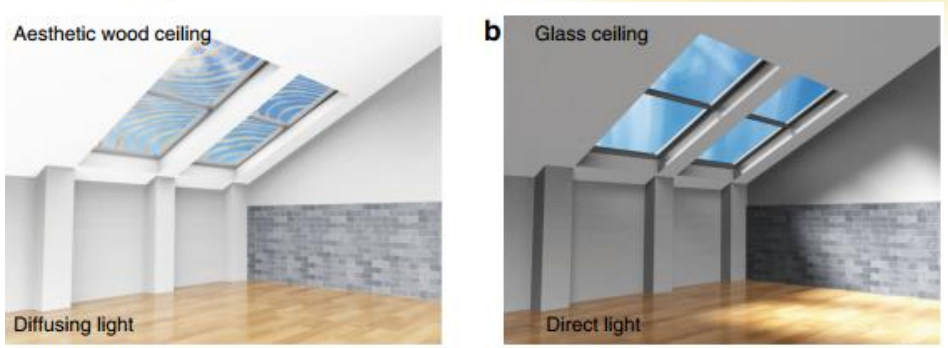
Refractive index matching



Transparentes Holz

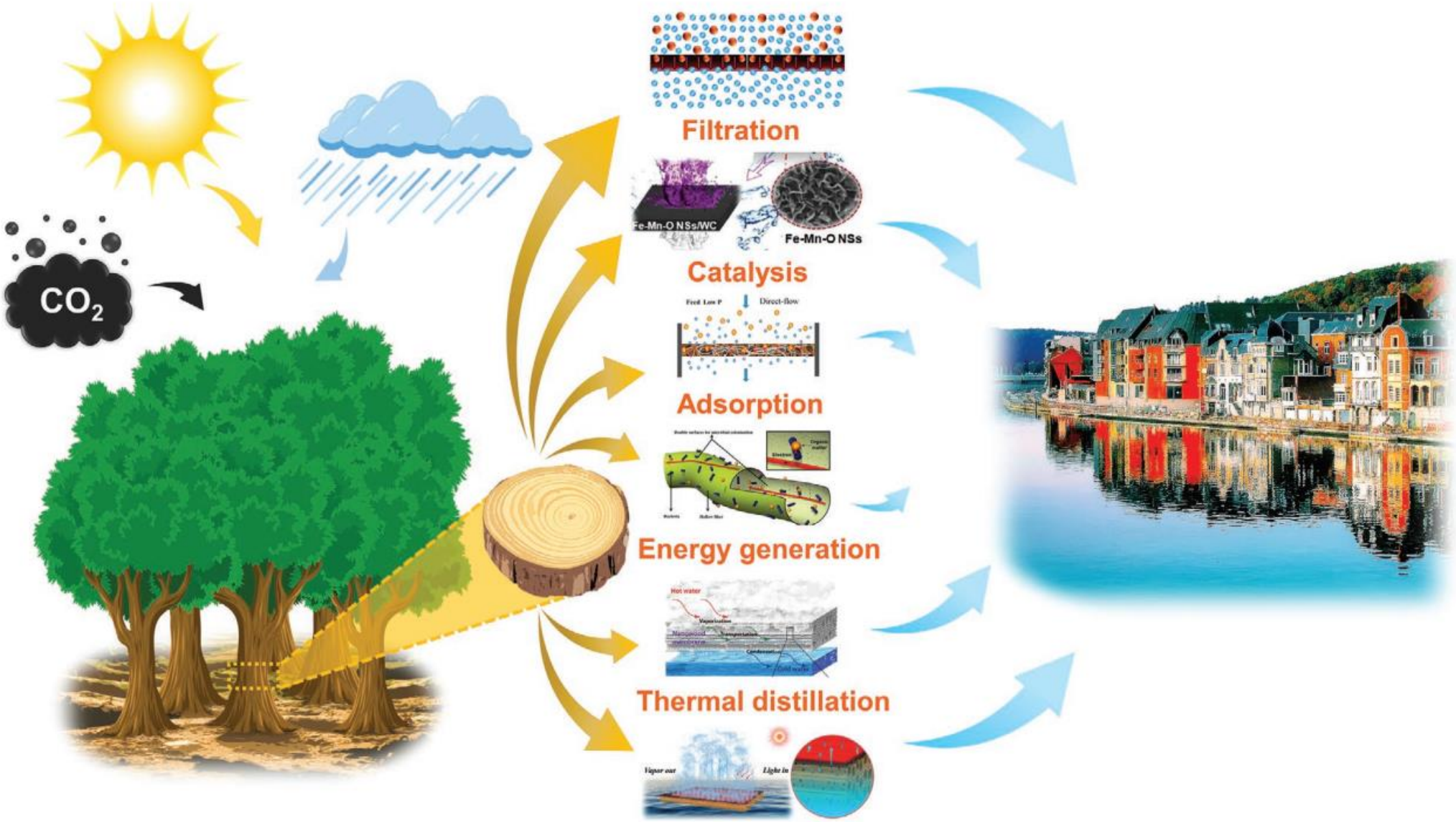


Li et al. 2016, Adv. Energy Mater., 6



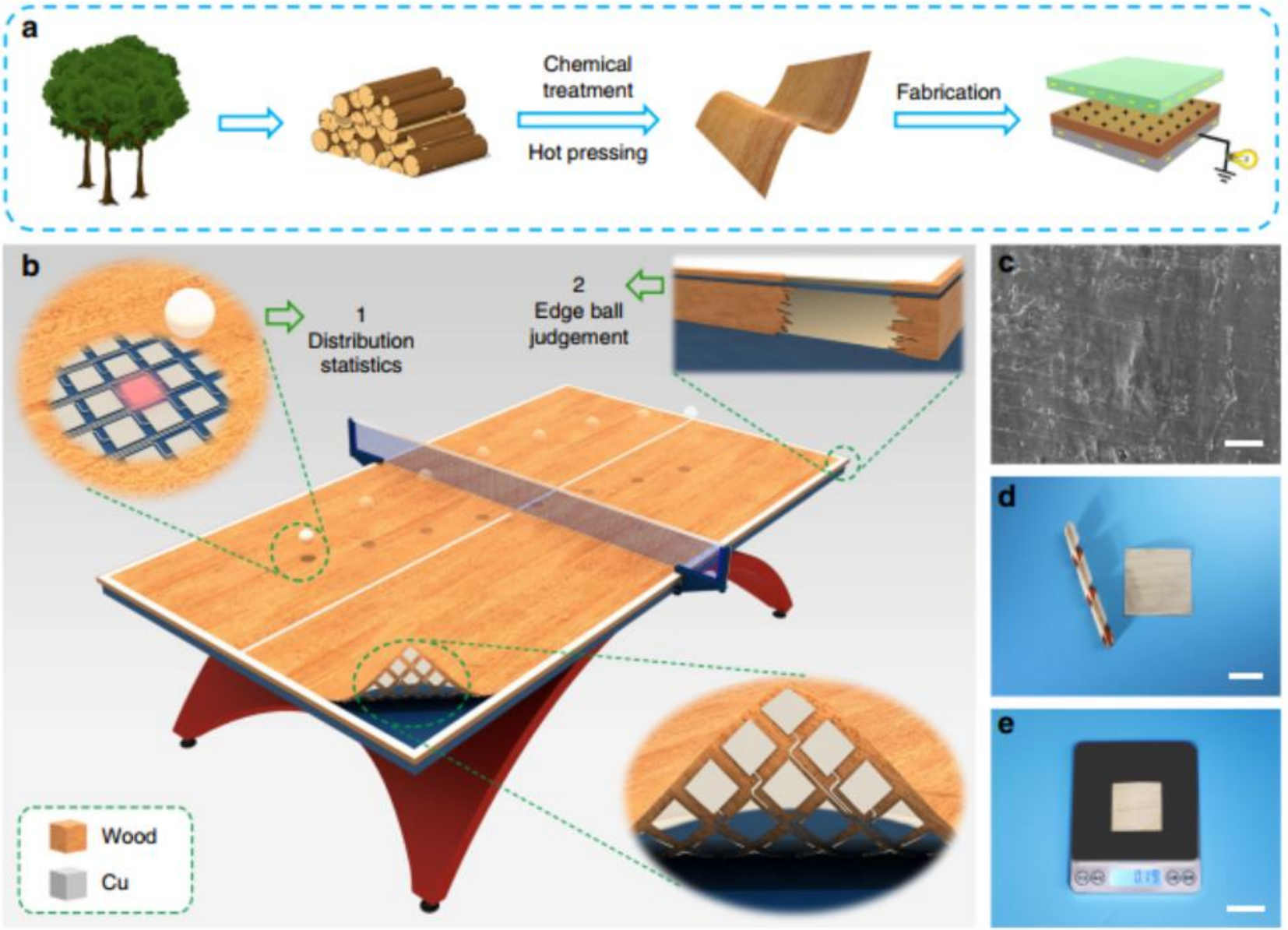
Mi et al. 2020: Nature Comm 11

Holz-Nanomaterialien –Anwendungen der Zukunft



Chen et al. 2021 Adv Mat 33

Energiegewinnung mit triboelektrische Holz-Nanogeneratoren



Luo et al. 2019: Nature Comm 10

„Magnetisches Holz“ - Anwendungen

„Wir können uns mit Holz aus der Klimakrise herausbauen“

Hans Joachim Schellnhuber

The **willow experiment** by
Johan Baptist van Helmont
1580 –1644

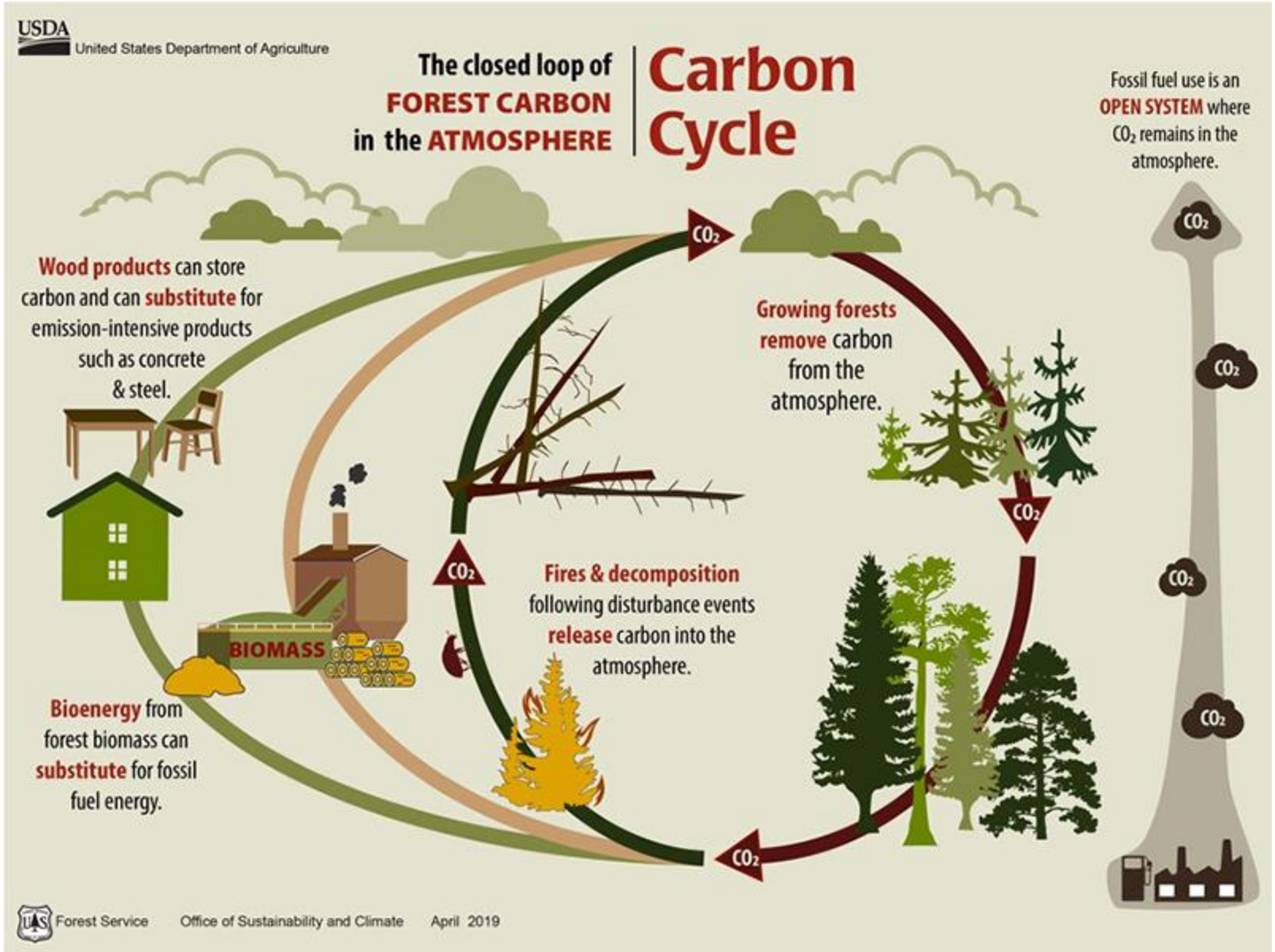
chemist, physiologist, and physician from Brussels.

Start:
Mass willow= 2,27 kg

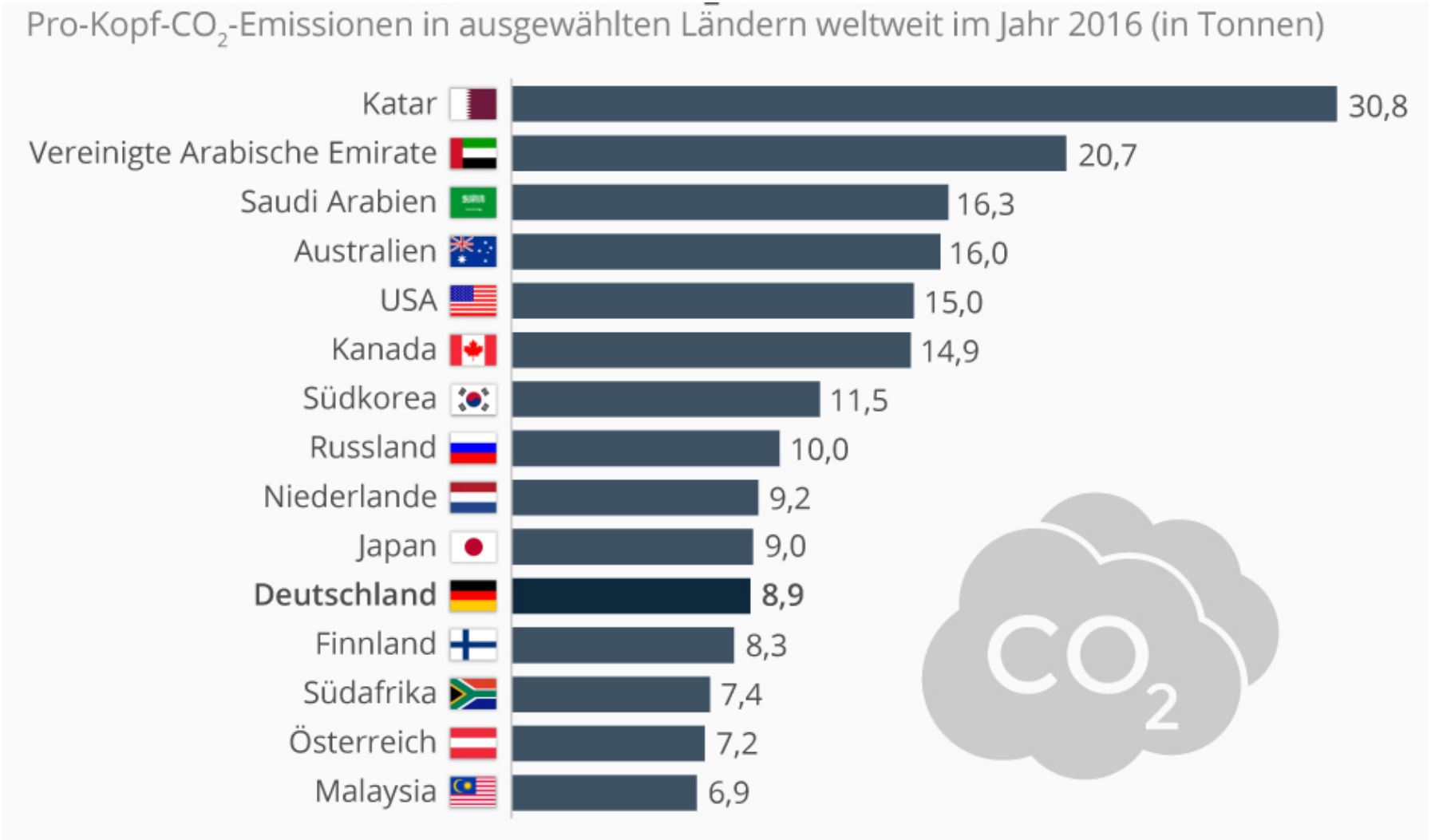
After 5 years:
Mass willow = 72kg

Mass pot + dry soil = 100kg

Mass pot + dry soil = 99,4kg


USDA
United States Department of Agriculture
The closed loop of
FOREST CARBON
in the ATMOSPHERE
Carbon Cycle
Fossil fuel use is an
OPEN SYSTEM where
CO_2 remains in the
atmosphere.
Wood products can store carbon and can substitute for emission-intensive products such as concrete & steel.
Growing forests remove carbon from the atmosphere.
Fires & decomposition following disturbance events release carbon into the atmosphere.
BIOMASS
Bioenergy from forest biomass can substitute for fossil fuel energy.
CO_2
Forest Service
Office of Sustainability and Climate
April 2019

Kohlenstoffemissionen – Pro Kopf



Janson, M. (3. Dezember, 2018). Katarer sind die größten CO2-Sünder [Digitales Bild]. Zugriff am 24. Januar 2024, von https://de.statista.com/infografik/16282/co2-emissionen-pro-kopf/