HZB BESSY II Light Source

Lightsources Meet Their Responsibility

Synchrotrons Building the Global Scientific Community

Antje Vollmer

BESSYII@HZB

Outline

BESSY II and her sisters in the world

Users and user communities

Our Mission

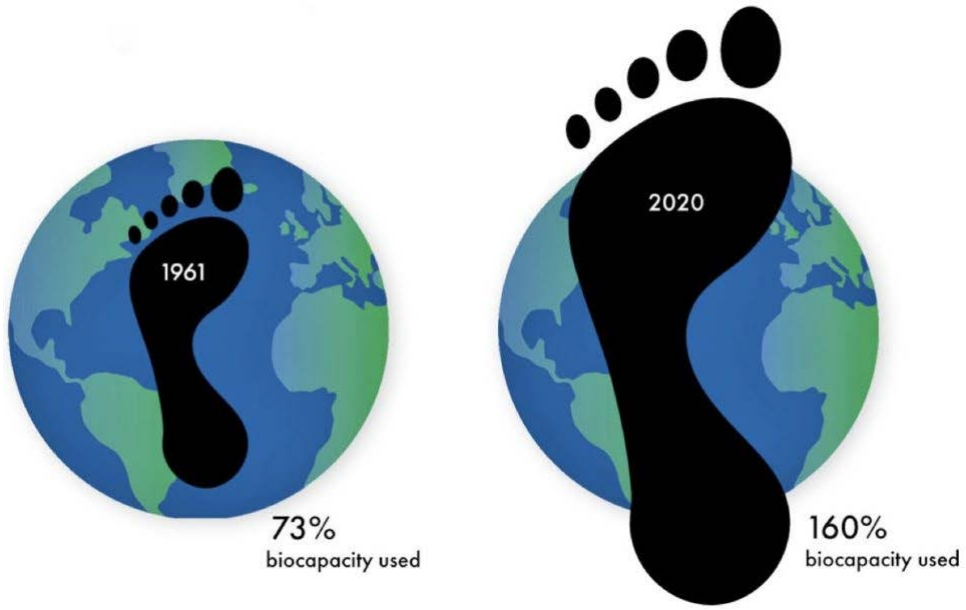
Challenges and solutions

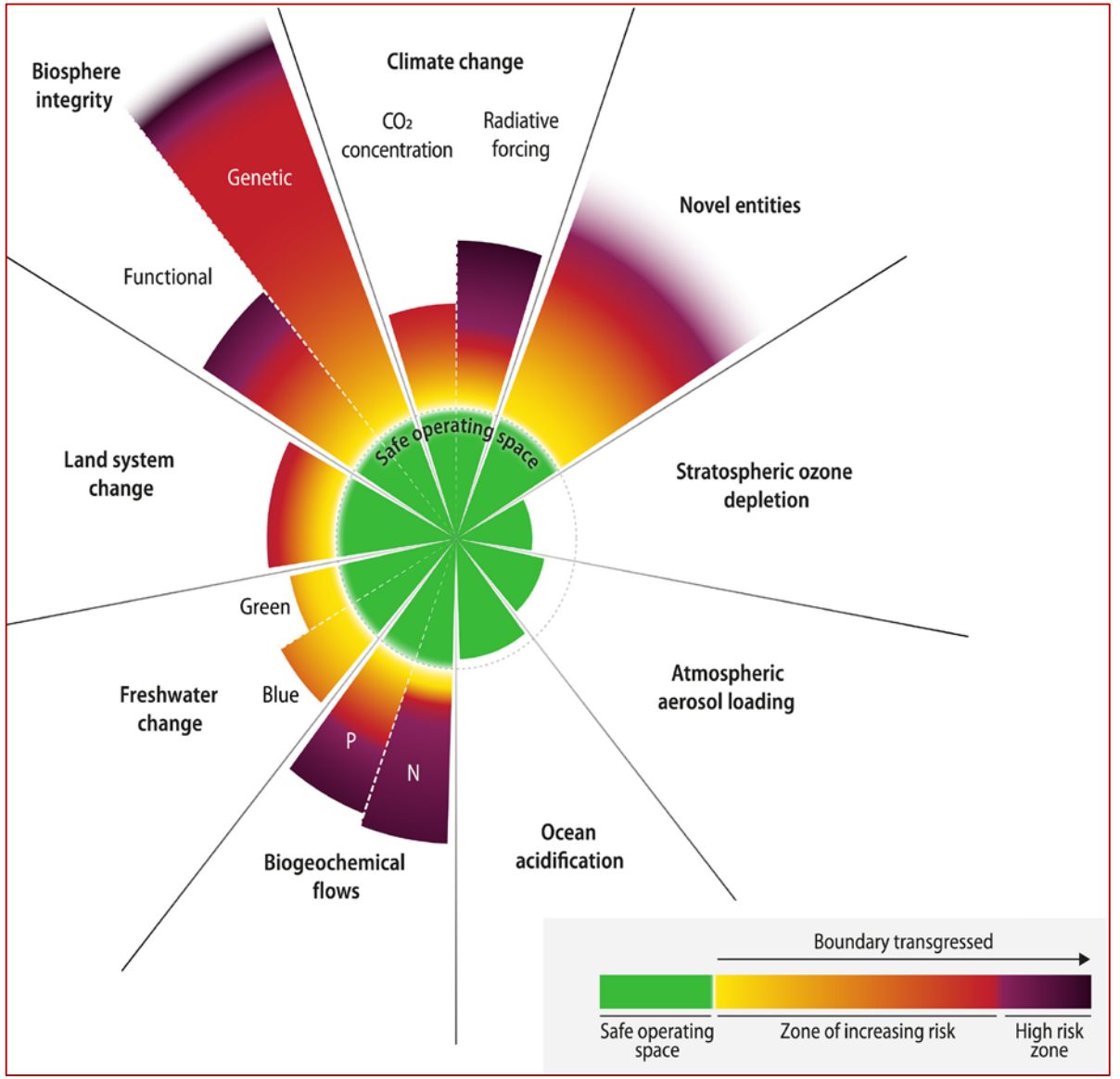
Beyond brilliant science

Africa and Science Diploamcy

1

Our planet is stressed and not in good shape





Earth beyond six of nine planetary boundaries

Science Advances, DOI:10.1126/sciadv.adh2458

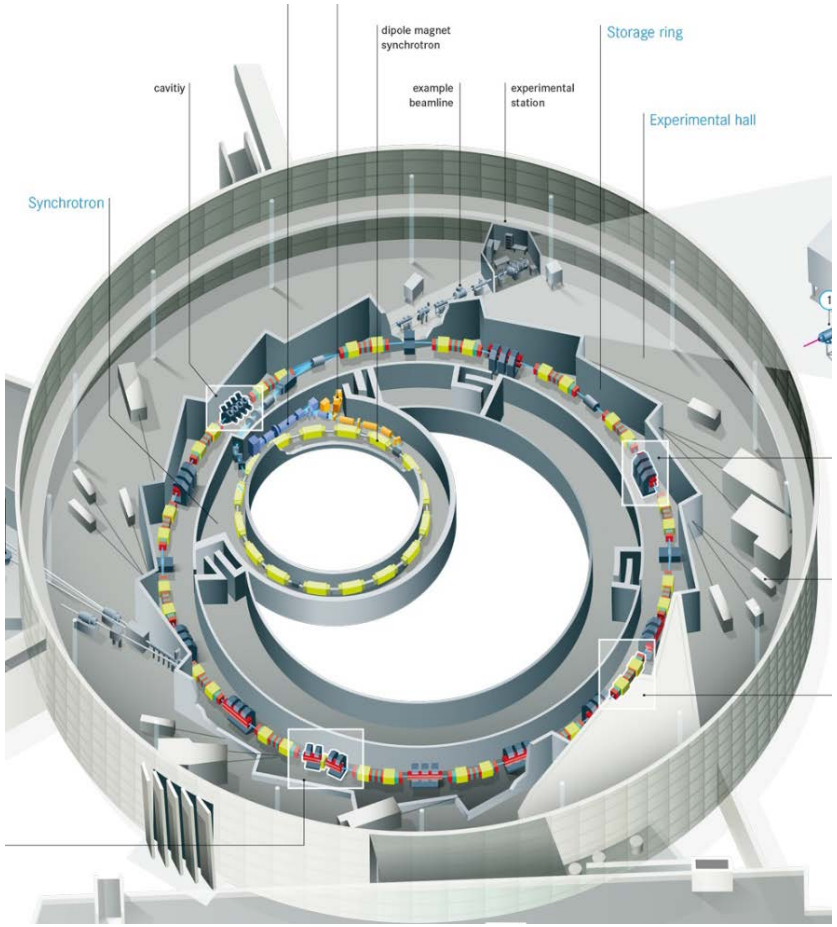
2

Talent is evenly distributed around the globe

–

while opportunities are not

BEESY II – who we are



At BESSY II: synchrotron light at 40 experimental stations in user operation

Verstile infrastructure for a multitude of scientific fields

Expertise, support and collaboration

Beamtime is free of charge, travel costs partly reimbursed

26 years of User Operation at BESSY II

More than 12000 publications
More than 4000 protein structures
More than 30000 proposals from 58 countries

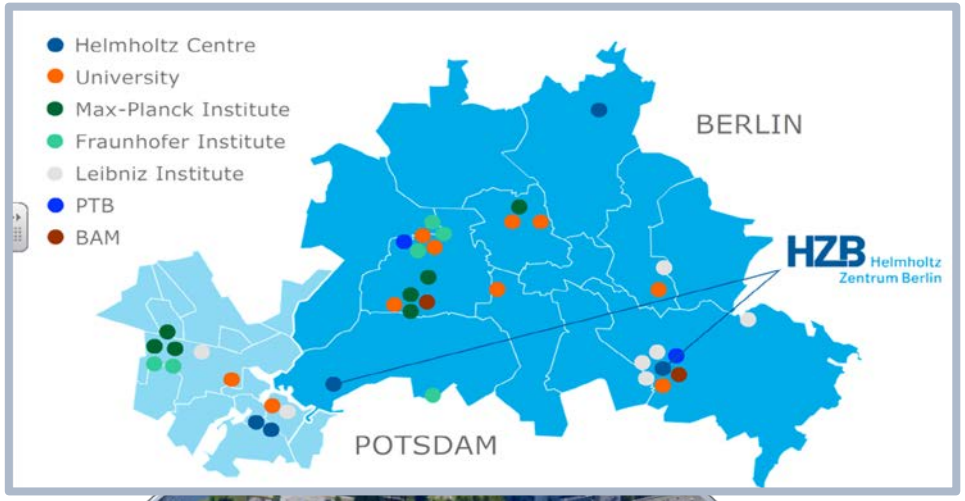
50 beamlines in operation, thereof

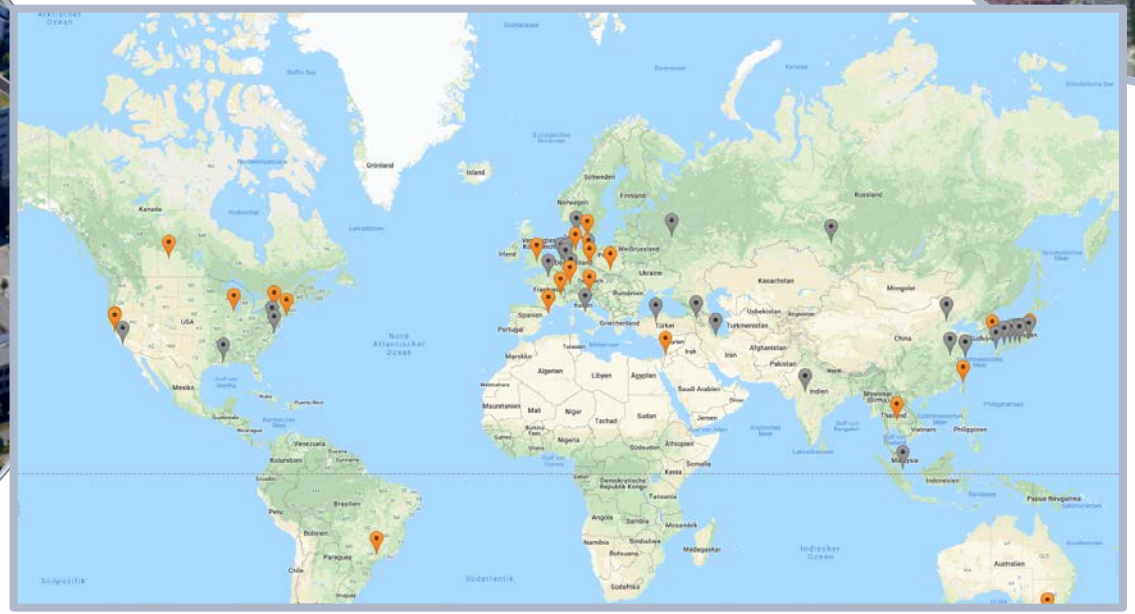
40 beamlines in user operation

Synchrotrons of the world

NEPHEWS

LEAPS

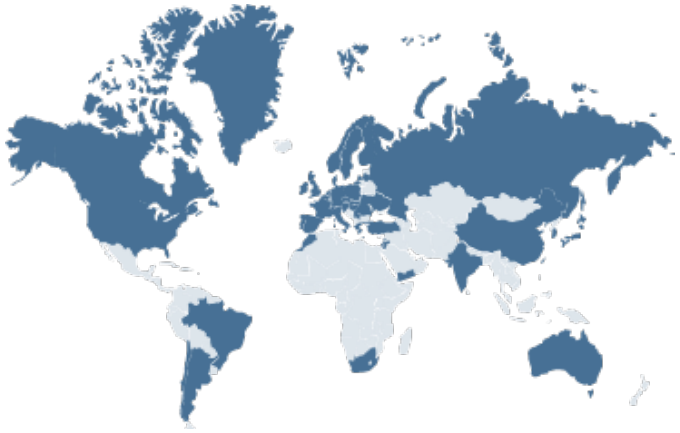




The world is visting BESSY

1995

2005



2015

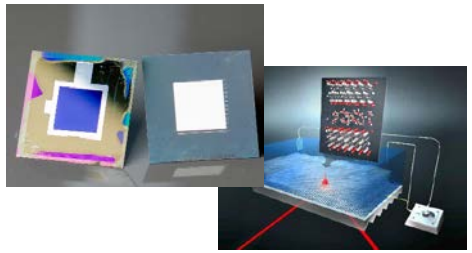
2025

Average numbers per year

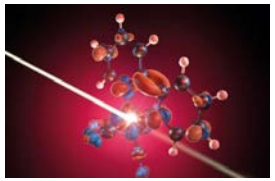
- More than 1200 proposals per year
- About 800 beamtime campagnes

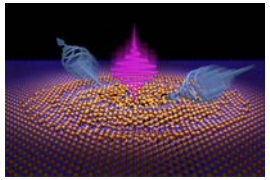
- Up to 2700 user visits
- More than 12000 registered users
- More than 500 verified publications

BESSY II– Multitude of users and research fields

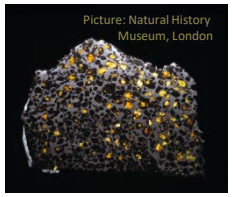


Energy and PV

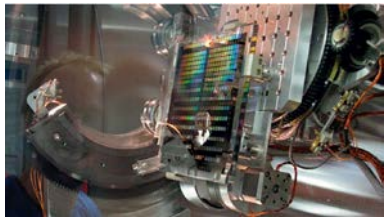




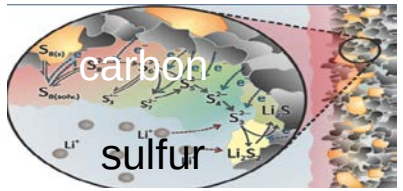
Functionality of matter



Space

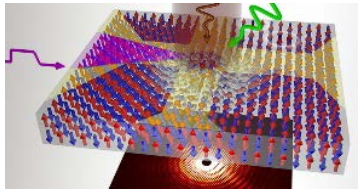


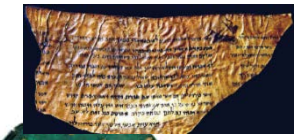
Metrology



Batteries

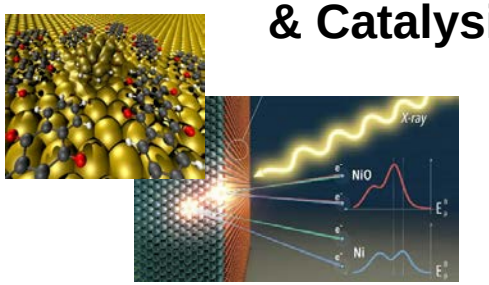
Quantum Materials
Information



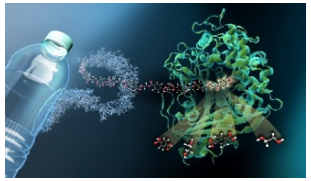


Cultural
Heritage

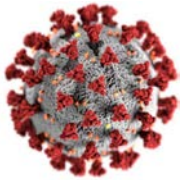
Chemistry
& Catalysis



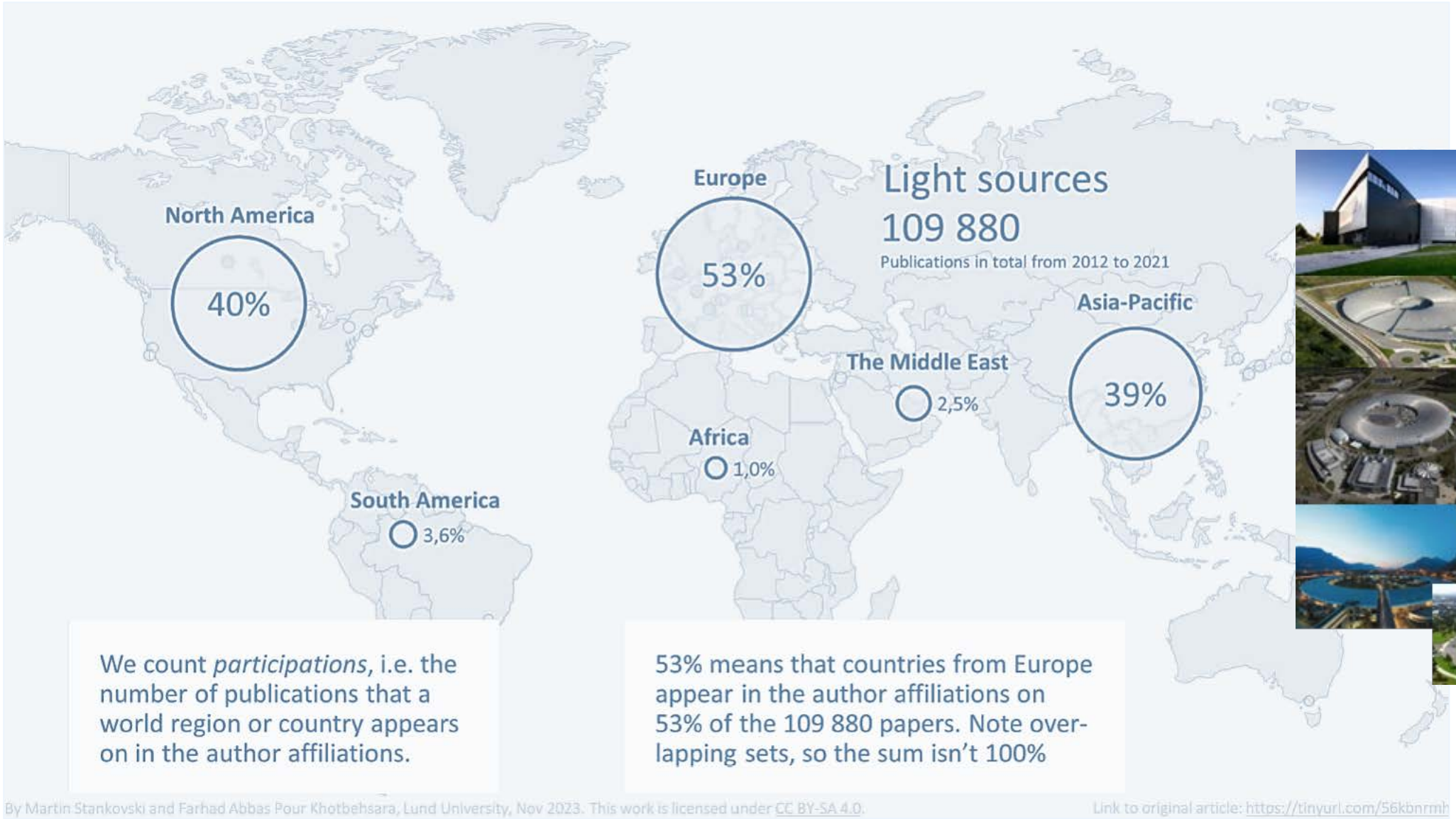
Environment



Medicine
& Biology



Publication output – synchrotron are power houses



https://www.linxs.se/news/article-series-i/size-of-the-global-light-and-neutron-source-communities






Mission HZB

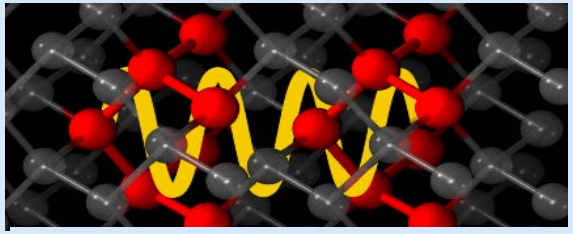
OUR VISION 2030+: Based on novel materials we develop technological solutions and so we shape a sustainable future

We strive to achieve a climate neutral society through science and innovation

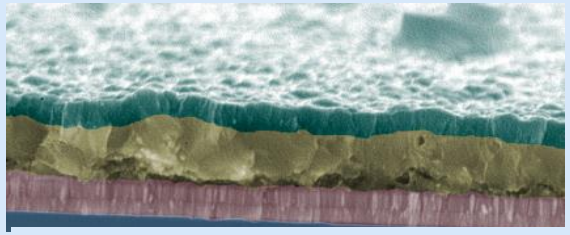
This is why

- we drive materials discovery
- create new sustainable technologies
- empower the global research community in realizing this goal

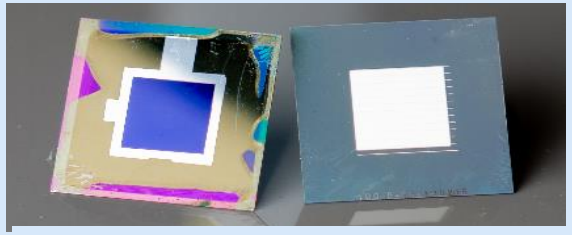
In pursuing our mission, we are committed to our social and environmental responsibility in our research and our daily work



Atoms



Interfaces



Devices

System Integration



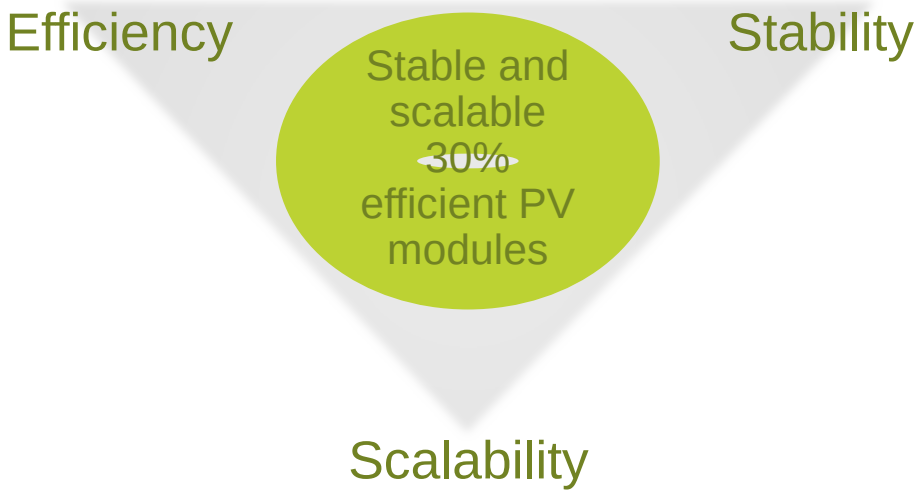


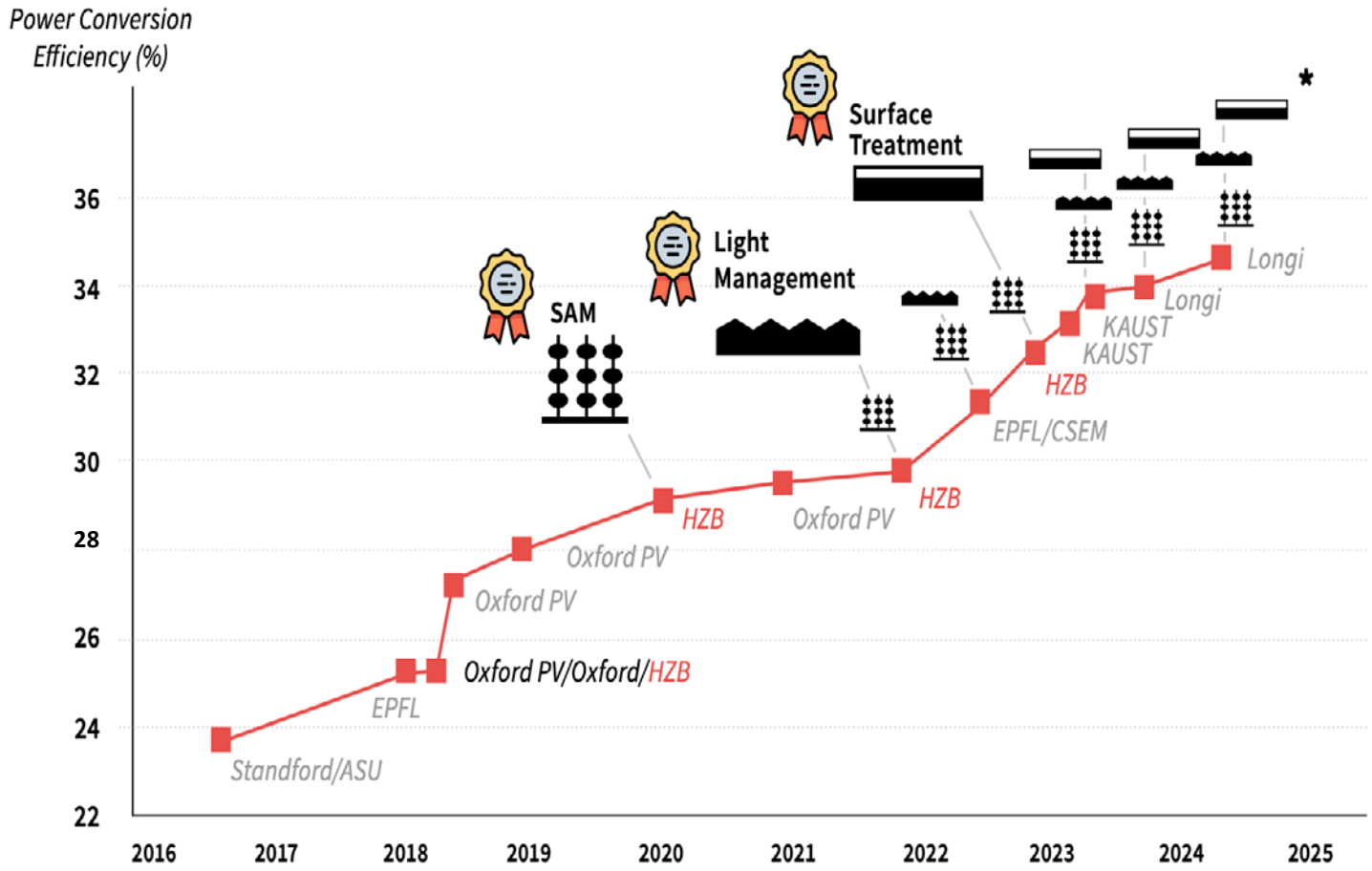

Photovoltaics

60 Minutes: the sun delivers the energy the whole world needs in one year[1]

567x567 km²:
of solar panels in the Sahara (3,5% of the area) would satisfy the world‘s energy demand.

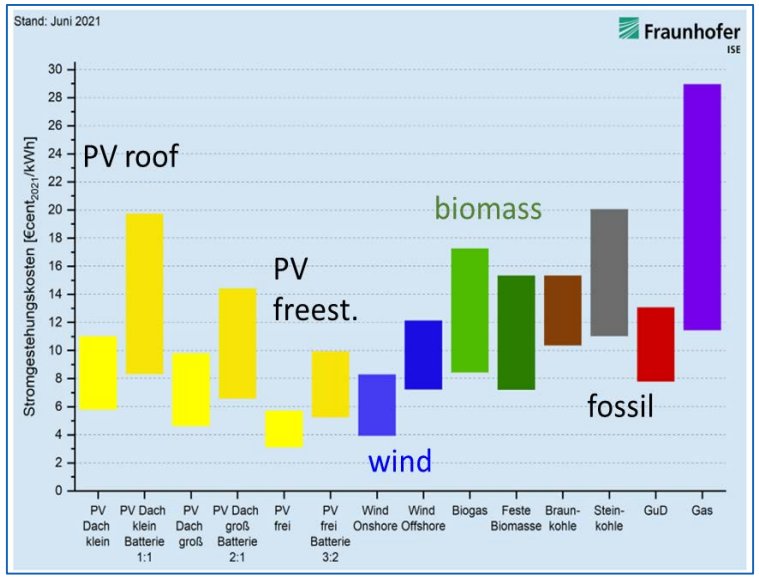
22m²
Of solar panels cover the need of an average household



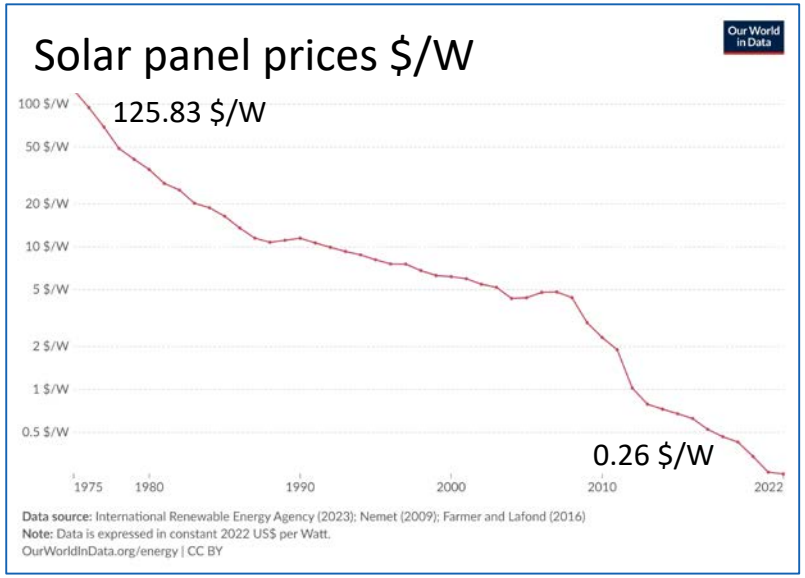


[1]BP Statistical Review of World Energy 2018, 67th edition 2018, Weltenergieverbrauch 2017: 157135,25 TWh

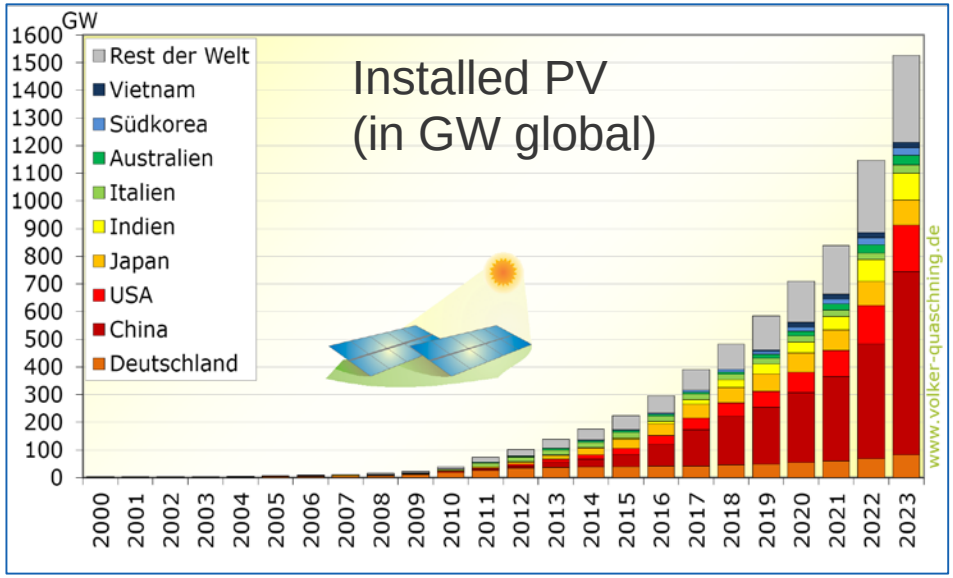
Photovoltaics



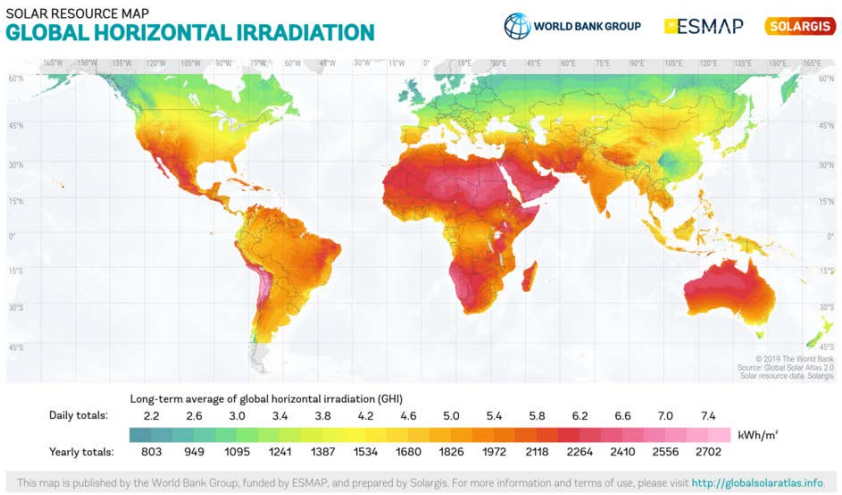
https://www.ise.fraunhofer.de/de/



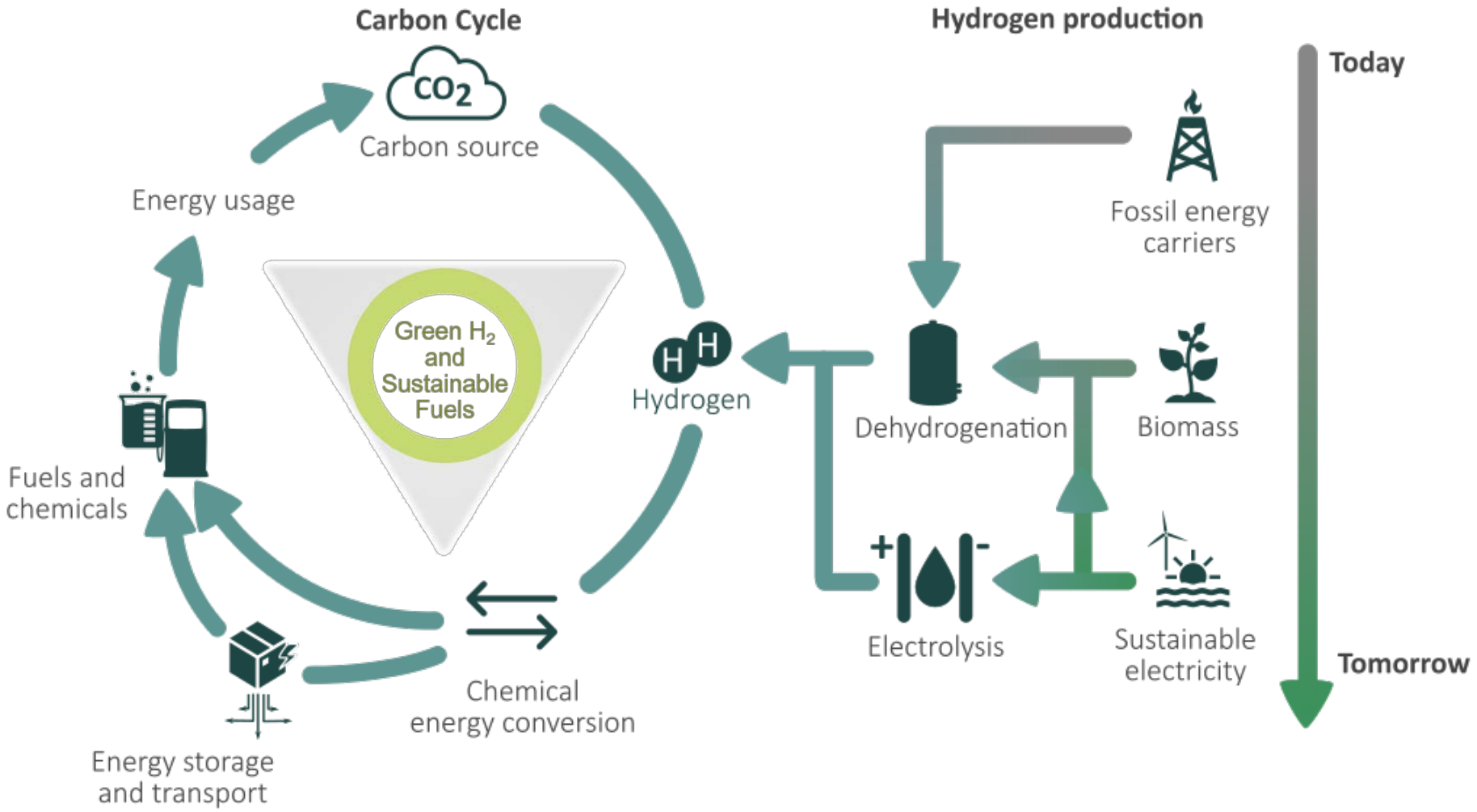
Inernat. Renewable Energy Agency 2023



https://www.volker-quaschning.de/datserv/index.php



Fossil Fuel-Free Society



Hydrogen Demand (2023)

- Global H_2 production was 97 Mt (8 Mt in Europe)
- Fraction of H_2 that is green: 0.03% → 0.4% (‘20→’23)
- EU Target: 10 Mt/yr by 2030 (FID: 1.9 Mt/yr globally!)
- Alternatives: imports, CCS

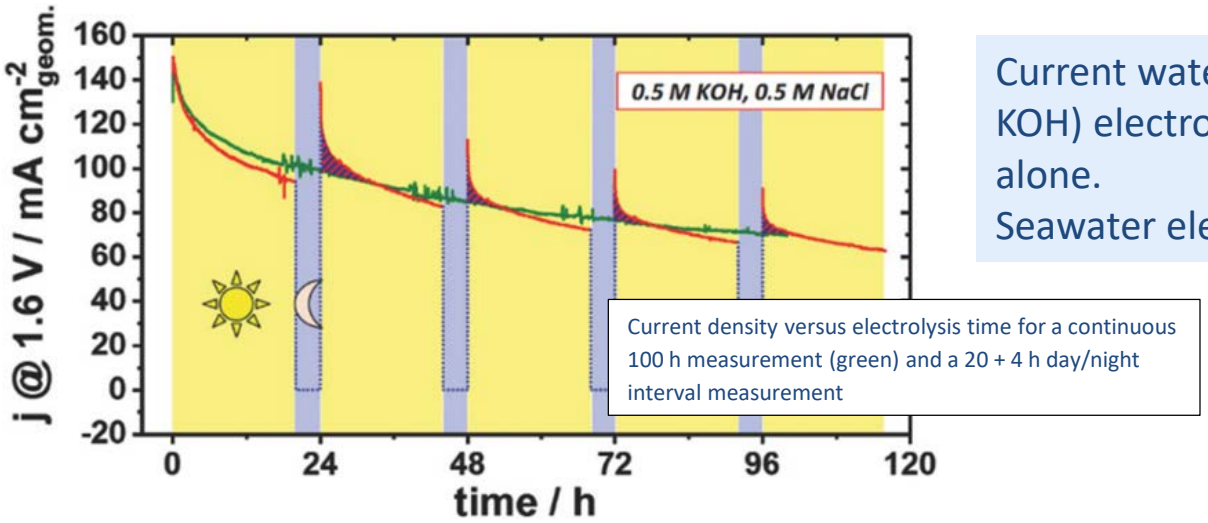
Green H_2: enormous growth potential!

Sources:
- *Global Hydrogen Review 2021, 2024*, IEA
- *Clear hydrogen monitor 2024,* Hydrogen Europe

Highlight – energy

operando

Oversalted? That's good! Electricity only during the day?
An advantage! Direct electrolytic splitting of seawater



Current density versus electrolysis time for a continuous 100 h measurement (green) and a 20 + 4 h day/night interval measurement

Current water electrolyzer technologies only split either highly alkaline (20–40 wt% KOH) electrolyte obtained from purified freshwater or else purified freshwater alone.
Seawater electrolysis faces fundamental chemical challenges

- First efficient working alkaline electrolyzer, splitting artificial alkaline seawater, based on nanostructured NiFe-layered double hydroxide (anode) and Pt nanoparticles (cathode).
- The natural day-night cycles could function as a refreshment protocol when using renewable energy sources like photovoltaics or wind power to operate the electrolyzer.
- Direct use of the vastly more abundant seawater supplies could solve the problematics related to scarce water provision and high fresh water demand, which are severe in many arid zones.

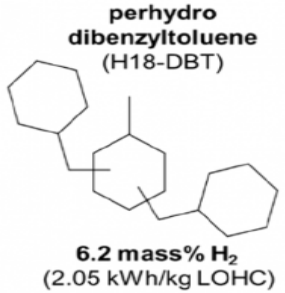
FU/TU Berlin

Adv. Energy Mater. 2018, 8, 1800338 DOI: 10.1002/aenm.201800338, BESSY II Instrument KMC3-XPP

Highlight – energy storage

Towards a Hydrogen-free Hydrogen Economy – just borrow H from a molecule

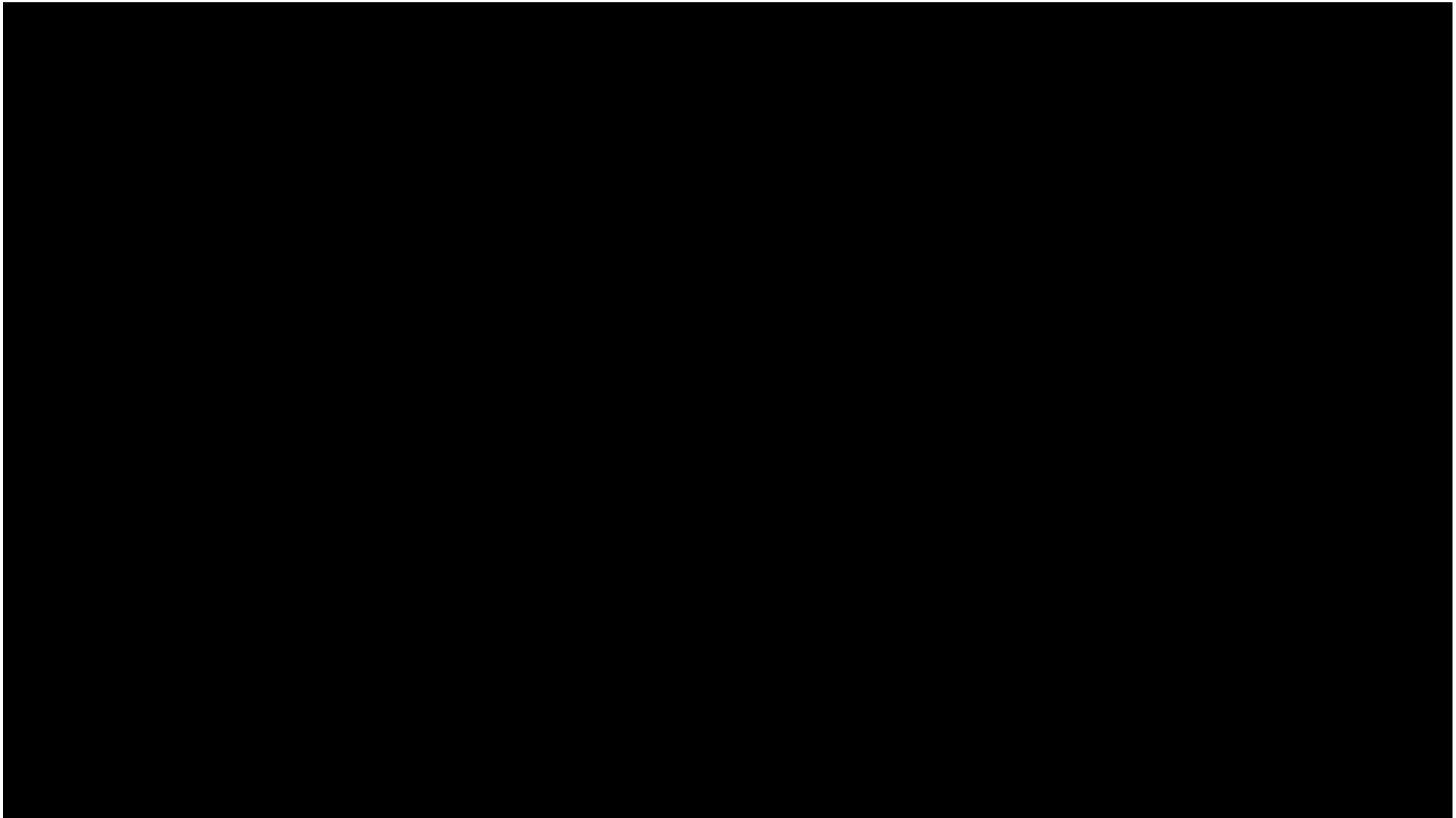
The nature of hydrogen requires dedicated infrastructures. So far this has prevented the introduction of elemental hydrogen into the energy sector to a large extent.



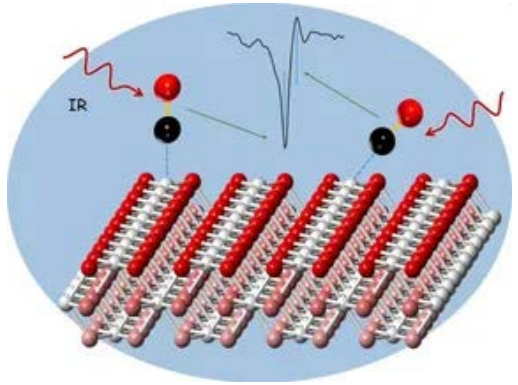
- liquid organic hydrogen carrier (LOHC): pairs of hydrogen-lean and hydrogen-rich organic compounds.
- A future hydrogen economy may work without handling large amounts of elemental hydrogen.
- Repeated catalytic hydrogenation and dehydrogenation cycles.
- Use of the existing infrastructure for fuels, public confidence in dealing with liquid energy carriers.

FAU Erlangen

Acc. Chem. Res., 2017, 50 (1), pp 74–85,doi:10.1021/acs.accounts.6b00474, BESSY II Instrument UE56/2 and U49



The Catalyst Challenge



Carbon Cycle

CO_2

Carbon source

Energy usage

Fuels and chemicals

Energy storage and transport

Chemical energy conversion

Green H_2 and Sustainable Fuels

Hydrogen

Hydrogen production

Fossil energy carriers

Dehydrogenation

Biomass

Electrolysis

Sustainable electricity

Today

Tomorrow

CAT 1

CAT 2

CAT 3

CAT 4

CAT 5

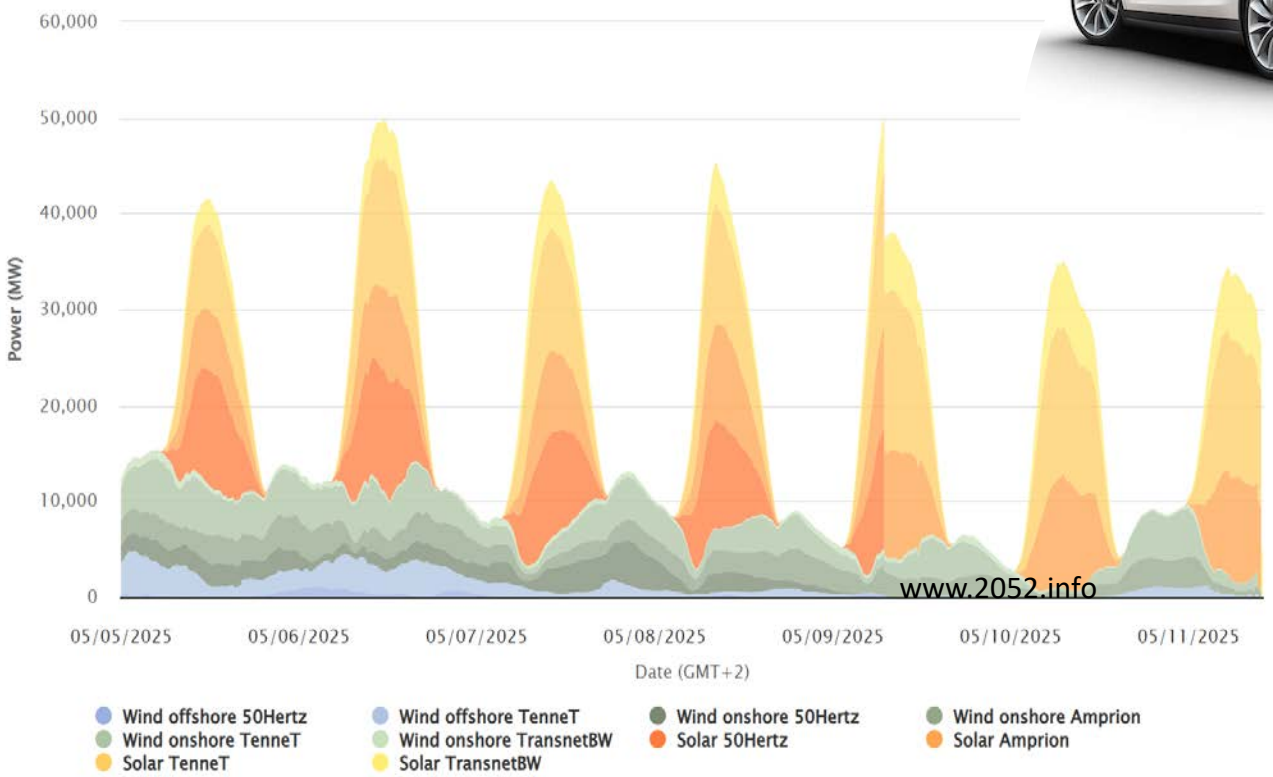
CAT 6

CAT 7

CAT 8

CAT 9

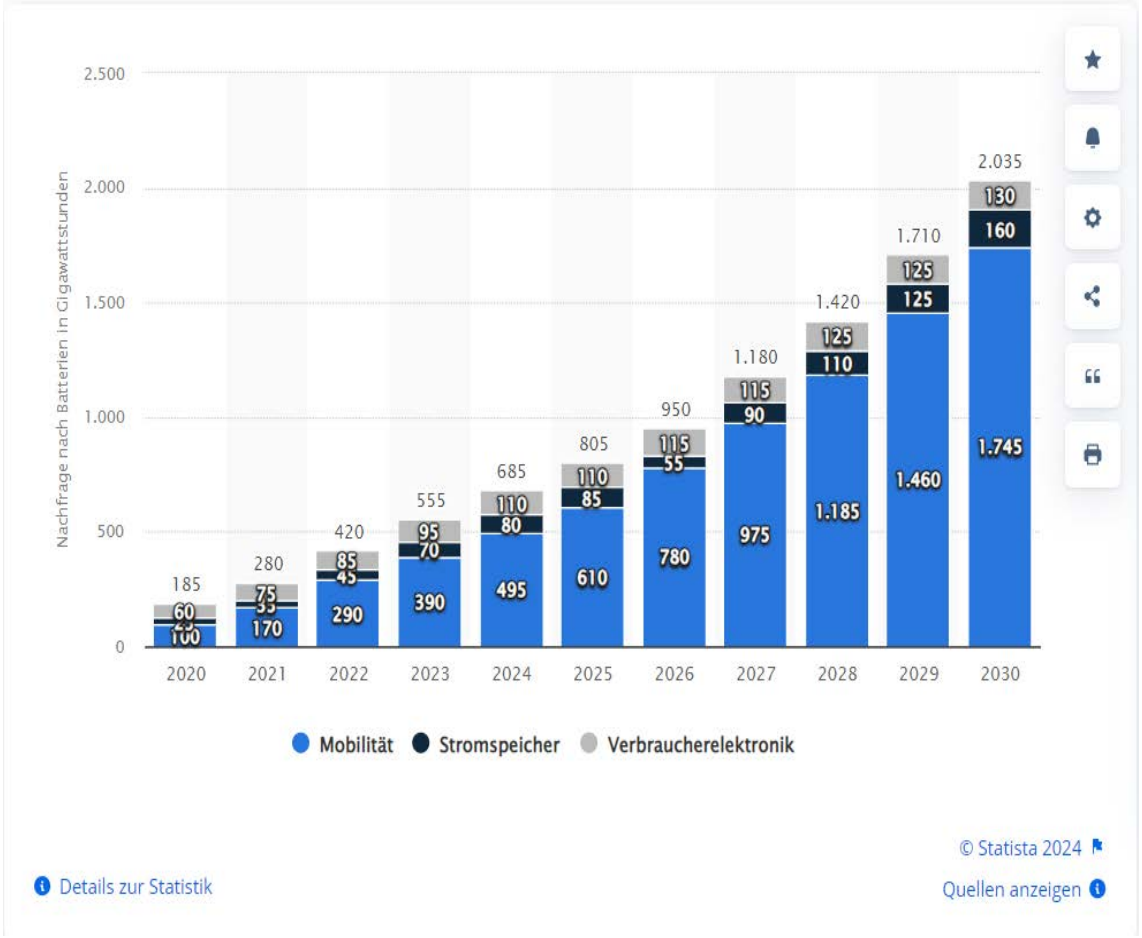
Efficient energy storage system is needed!



www.2052.info

Growing demand for energy storage

Global demand for batteries (GWh) 2020-2030

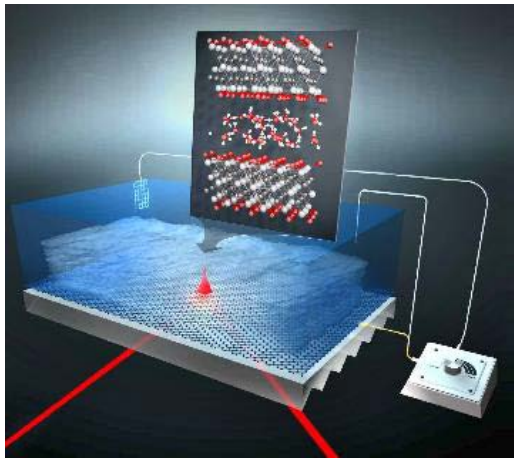


Technical objectives (batteries)

Increase energy density
Increase power density and charging rate
Improve cycle life time
Reduce battery cost
Ensure safety
Improve sustainability and recyclability

Challenge: No Lithium, no nobel metals

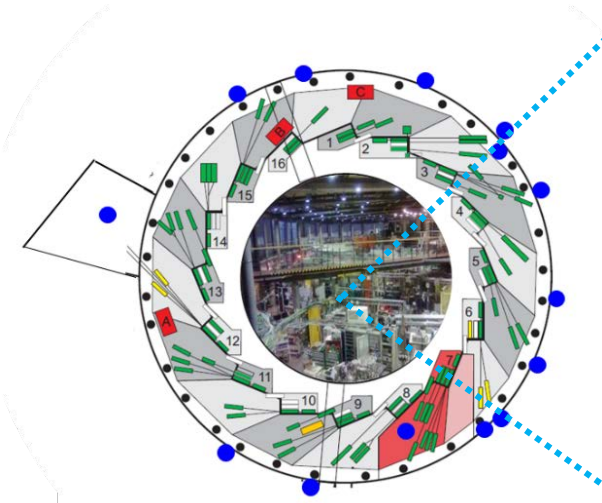
Highlight: Operando investigations – spy the battery – working, aging, failures



Superstore MXene: Combine talents of batteries and supercapacitors

Promising new material class for energy storage (“pseudocapacitors”)
Transport in water layers studied, combining BESSY II & lab techniques

Published in Nature communications (2023): Lounasvuori et al. DOI: 10.1038/s41467-023-36842-0



More than 20 national and international groups working on battery research

Currently at **12 BESSY II beamlines**

Applying **10 different scientific methods**

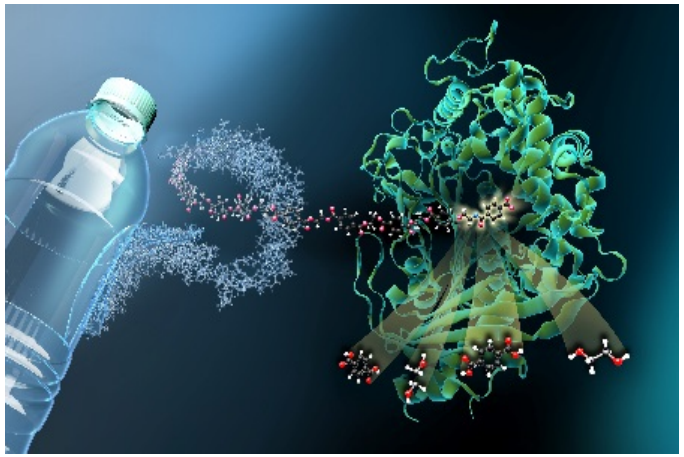
Crystallization seed for novel ideas and new user communities

Trigger for long term liaison and international cooperation with academia and industry

SAXS/WAXS
X-ray tomography/imaging; micro-XANES
NEXAFS, XPS
HAXPES
XANES, X-ray diffraction
UPS, XPS
ambient pressure XPS, XPS
XPS, NEXAFS
RIXS
X-ray Tomography, NEXAFS, in situ X-ray microscopy
XPS, ARXPS
XPS, XAS

Highlight - environment

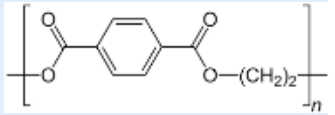
Combat plastic waste -a genuine recycling process for PET materials



MHET-molecules from PET plastic dock at the active site inside the MHETase and are broken down into their basic building blocks. © M. Künsting/HZB

Plastics are excellent materials: extremely versatile and almost eternally durable.

After only about 100 years of producing plastics, plastic particles are now found everywhere – in groundwater, in the oceans, in the air, and in the food chain.



50 million tons of PET (Polyethylenterephthalat) are newly produced every year

100 Mio

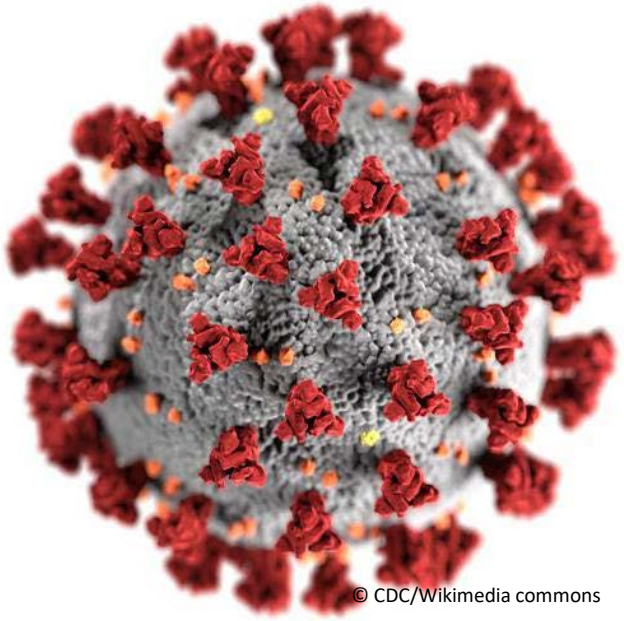
A yellow chain 4 times around the globe, just PET

- Discovery of a bacterium that grows on PET and partially feeds on it.
- Bacterium possesses two special enzymes, which are able to digest PET plastic polymers. one breaks down the plastic into smaller PET building blocks (“PET monomer”), the other splits this into the two basic precursor building blocks of PET, terephthalic acid and ethylene glycol.
- Synthesising new PET without the addition of crude oil, a closed sustainable production and recovery cycle.

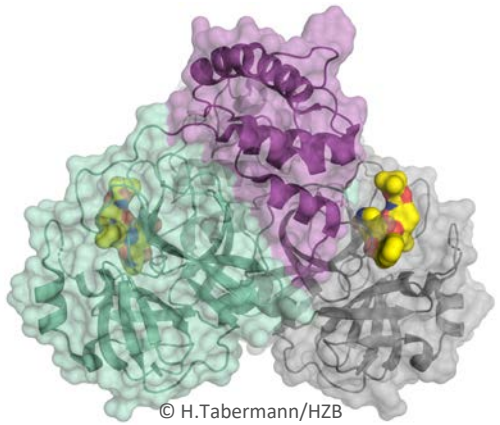
Uni Greifswald/HZB

Nature Communications (2019) DOI : 10.1038/s41467-019-09326-3, BESSY II MX-Beamline

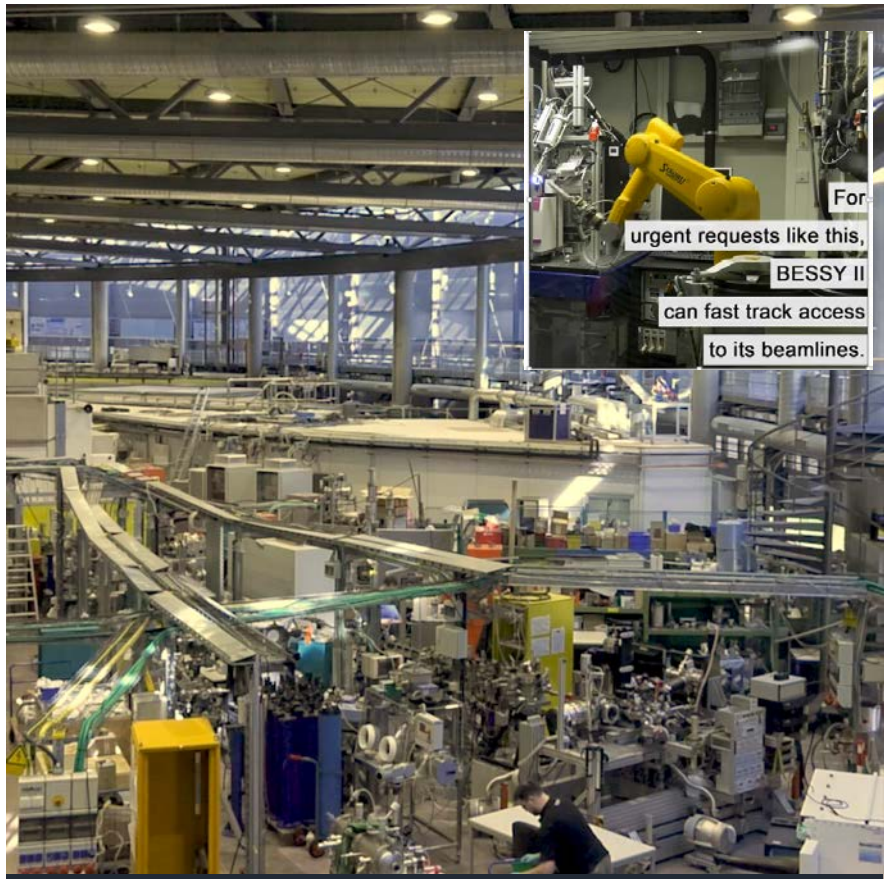
Corona Research at BESSY II



© CDC/Wikimedia commons



© H.Tabermann/HZB



https://www.helmholtz-berlin.de/forschung/unsere-forschung/photonenforschung/proteinkristallographie-an-bessy-ii_en.html

At BESSY II, Prof. Rolf Hilgenfeld (Uni Lübeck) was able to analyse an important protein of the SARS-CoV2 virus, the viral main protease which enables the virus to multiply.

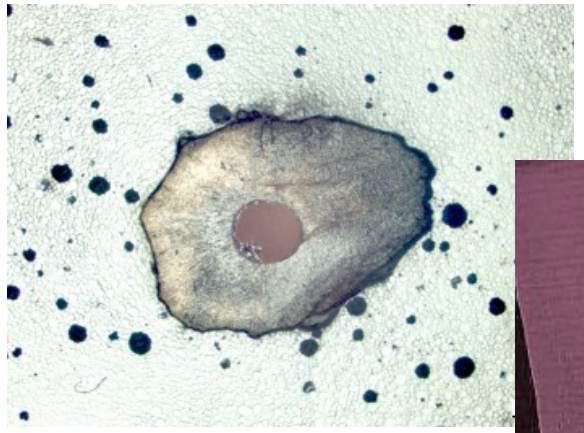
In the first year of the pandemic, synchrotron based research led to one Corona-relevant publication every 5 days!

Crystal structure of SARS-CoV-2 main protease provides a basis for design of improved α-ketoamide inhibitors
DOI: 10.1126/science.abb3405

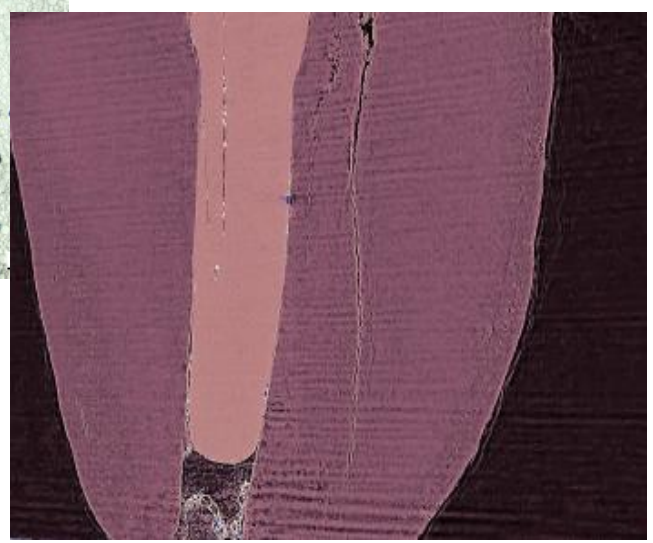
Uni Lübeck

DENTISTRY

Root canal treatment – not as bad as you think



Optical image of a filled root.
© P. Zaslansky



A section along a treated root canal (filling in pink) reveals dentine cracks by phase contrast-enhanced µCT.© P. Zaslansky

Root canal treatment is sometimes necessary….

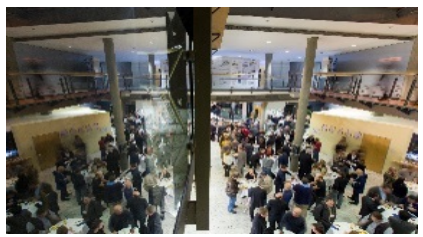
The procedure involves drilling an opening through the crown in order to reach the inflamed pulp and remove it.

One unfortunate possible complication is root fracture. Causes for such fractures are not fully understood, but it was suggested that stresses in the roots arising from the mechanical instrumentation may contribute to the appearance of cracks.

- Extracted teeth from the dental clinic at Charité were treated at a dental lab at the beamline and examined for possible cracks before, during, and after root canal treatment.
- The good news. Mechanical treatment is not contributing to micro fractures.

Charité Berlin

https://www.helmholtz-berlin.de/pubbin/news_datei?did=5491



Global challenges

The role of Science: discover, publish, innovate, share…

The role of Large Scale Research Infrastructures:
enable the best science
bring people together,
pave the way for peaceful cooperation

We need to bring people from all regions of the world together for the benefit of humans and society

https://www.lindau-nobel.org/a-driving-force-towards-peace-scientific-cooperation/ Picture: iStock.com/Rawpixel Ltd

SESAME

Synchrotron-Light for Experimental Science and Applications in the Middle East

Conceived late 1990s – two aims:

- Enable construction of a facility for a broad range of scientific research beyond the means of individual members
- Foster cooperation between peoples

SESAME

The current (2018) Members of SESAME are Cyprus, Egypt, Iran (Islamic Republic of), Israel, Jordan, Pakistan, Palestine, and Turkey

In 2019 SESAME became the world's first large accelerator complex to be fully powered by renewable energy

(some) lessons learned….

Science bridges Cultures
Acceptance of diversity is vital
Trust between people is a mandatory ingredient
Scientists can/should/must be ambassadors for peaceful cooperation

CERN and SESAME have become examples for Science Diplomacy…

BESSY II and her sisters in the world

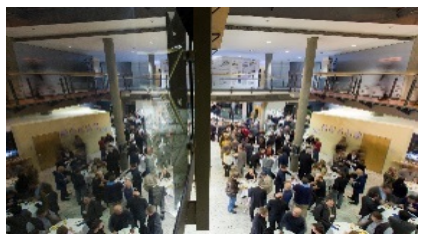
Users and user communities

Our Mission

Challenges and solutions

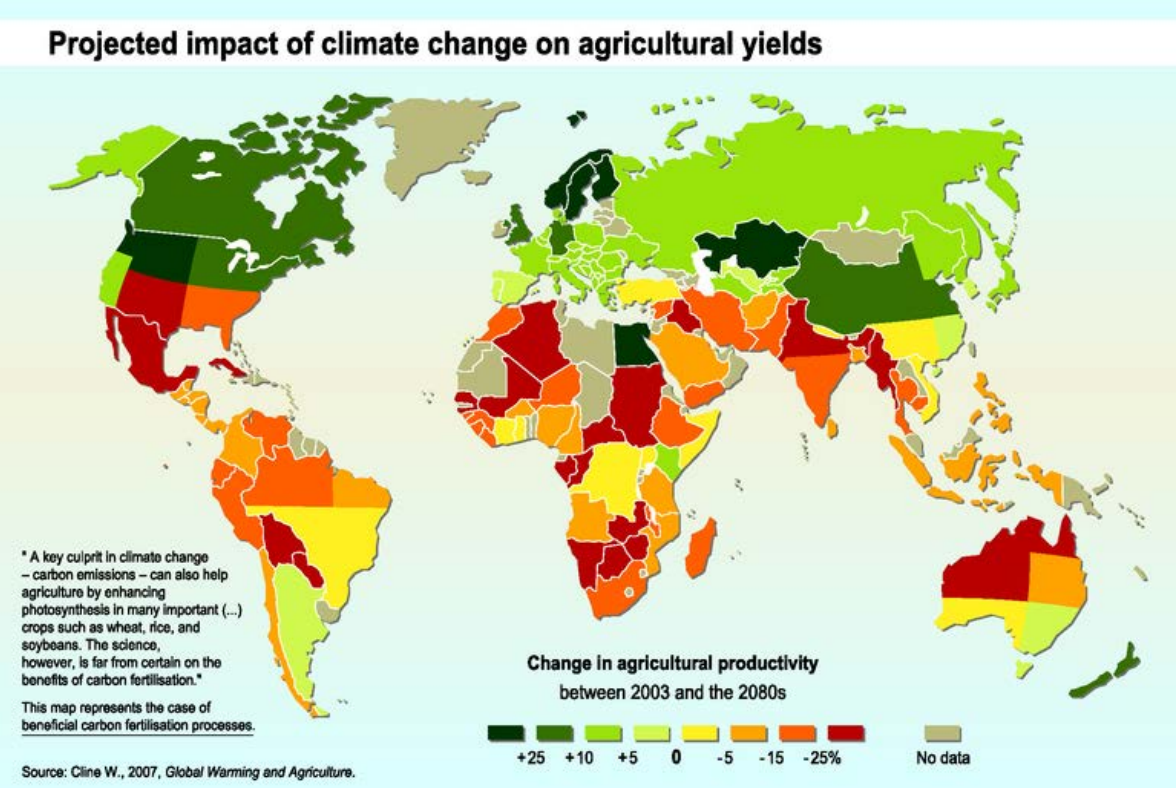
Beyond brilliant science

Africa and Science Diploamcy

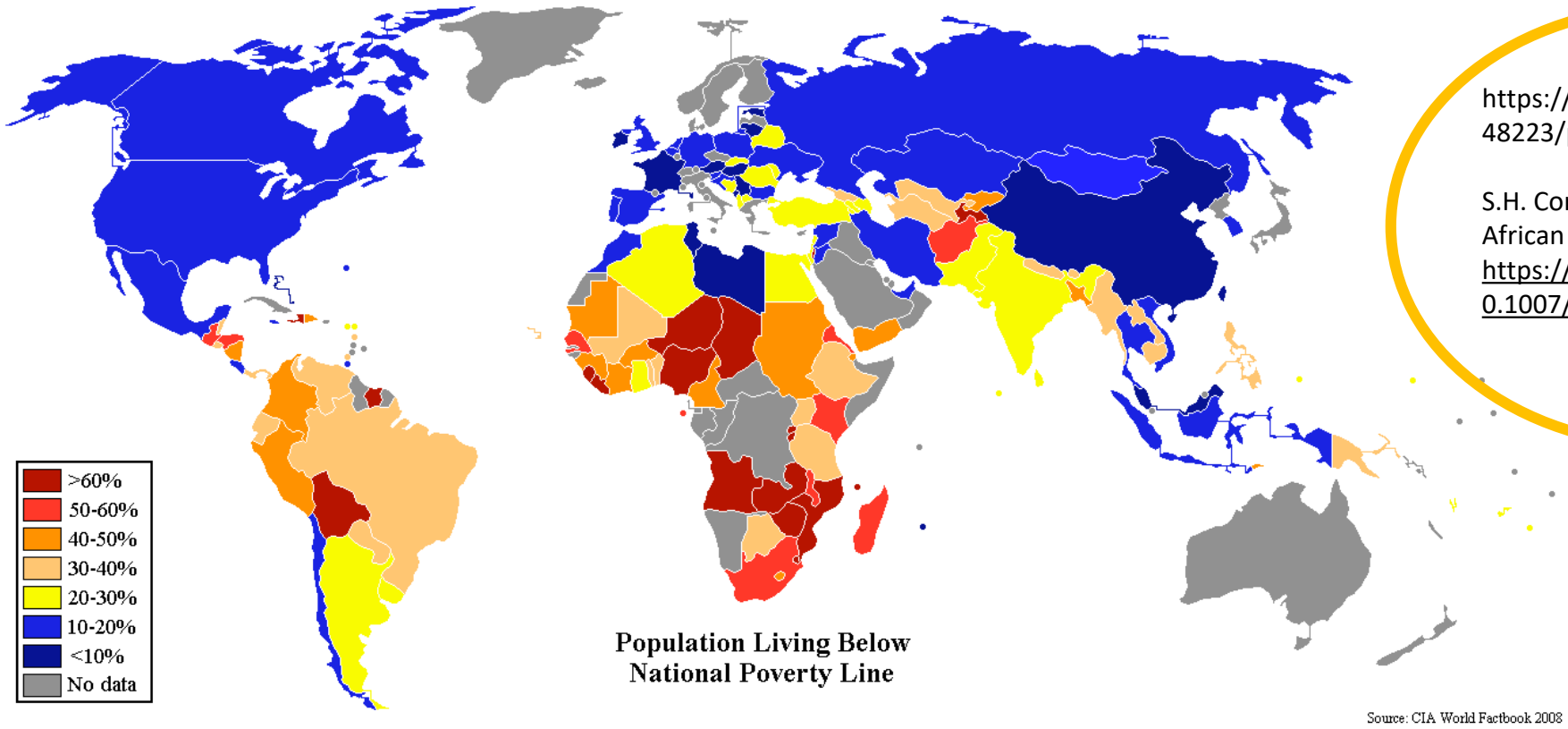


Africa and climate change

And now, please remember the research highlights: solar energy, water splitting from sea water, transport of hydrogen in existing infrastructures, using hydrogen for solar fuels (from alcohols to synthetic aviation fuel)



Africa and poverty



https://unesdoc.unesco.org/ark:/48223/pf0000235406

S.H. Connell et al., Towards an African Light Source, https://link.springer.com/article/10.1007/s12551-019-00578-3

Africa as a whole has 169 scientist per 1 million people (cf. Europe 20 times more), a number that has to increase drastically to achieve economic development through innovation.

S.H. Connell et al., Towards an African Light Source, https://link.springer.com/article/10.1007/s12551-019-00578-3

AFRICA

Currently, Africa as a whole has 169 scientist per 1 million people (cf. Europe 20 times more), a number that has to increase drastically to achieve economic development through innovation.

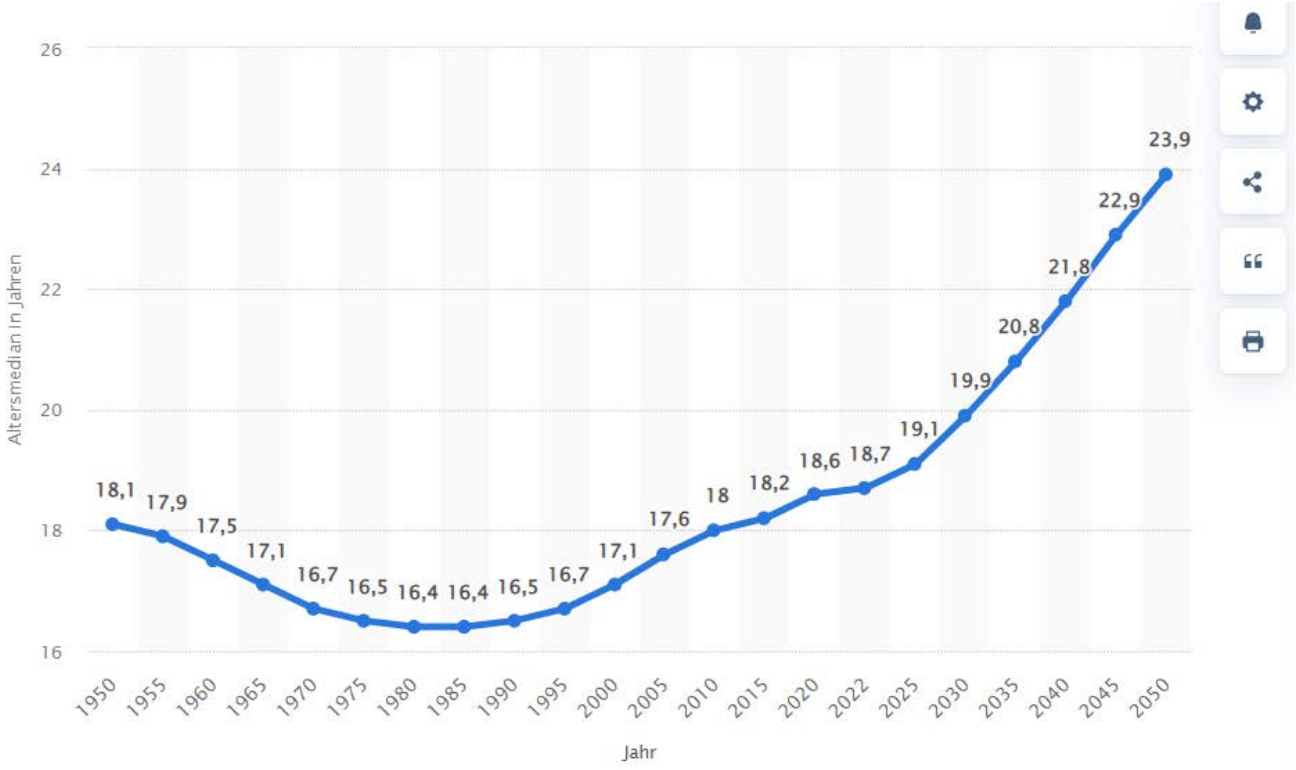
S.H. Connell et al., Towards an African Light Source, https://link.springer.com/article/10.1007/s12551-019-00578-3

But also:
every Euro spent in R&D creats 11 Euros for society.

Africa will soon become the home to the best part of the world's youth, these young people will need be part of the economy and developments in their countries.

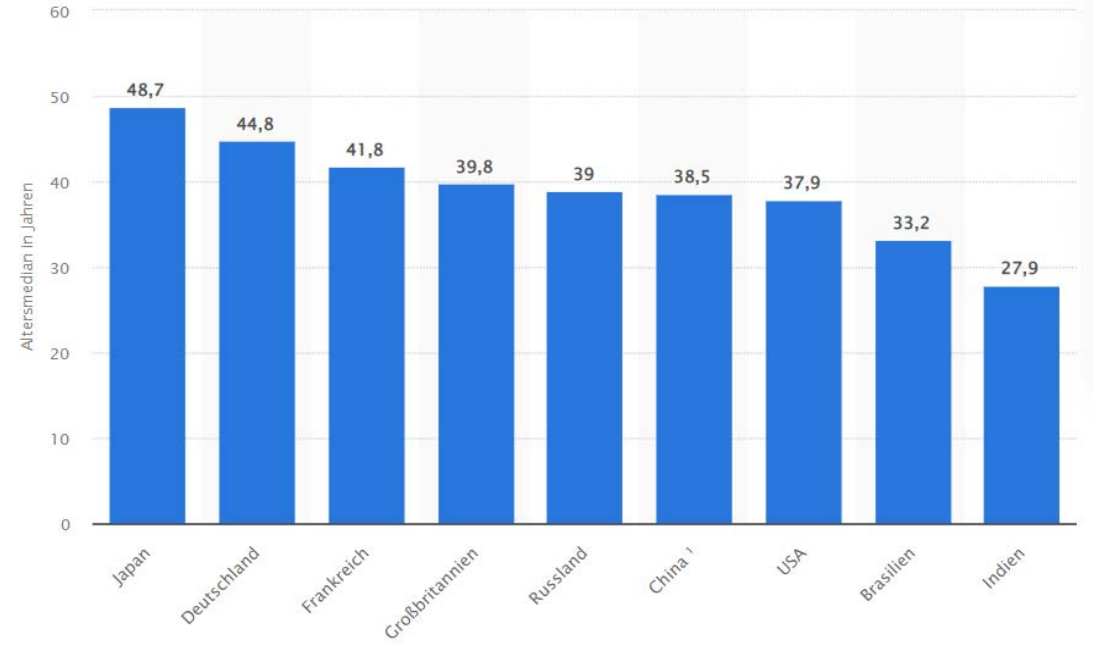
Average age in Africa: 23 years (Mali: 16.3)

AFRICA Median age



Details zur Statistik

Quellen anzeigen

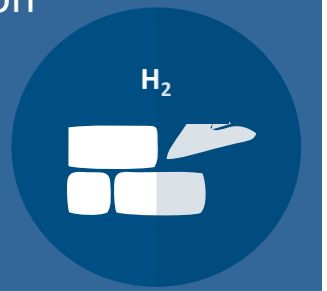


CARE-O-SENE

Catalyst Research for Sustainable Kerosene

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

- Renewable energy:
- Wind and Solar
- Green Hydrogen Production
- Carbon Air Capture
- Fuel Production
- Green Kerosene



https://care-o-sene.com/de_de/

Cyril Ramaphosa and Olaf Scholz at the CARE-O-SENE launch in May 2022

GreenQUEST

Fuel for Life

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Develop a viable, sustainable green fuel product (Green LFG) in the Global South, in particular sub-Saharan Africa

by combining technological process development with a holistic assessment of the entire Green LFG value chain's technical, economic, environmental, and social dimensions.

https://www.greenquest.africa/

50 researchers from South Africa and Germany work hand in hand

University of Cape Town · iYunivesithi yaseKapa · Universiteit van Kaapstad

HZB Helmholtz Zentrum Berlin

sasol reaching new frontiers

CSIR Touching lives through innovation

HYENA HYDROGEN ENERGY APPLICATIONS

GSB Graduate School of BUSINESS UNIVERSITY OF CAPE TOWN

JÜLICH Forschungszentrum

FUTURIA FUELS

catalysis institute

ESRG ENERGY SYSTEMS RESEARCH GROUP University of Cape Town

NELSON MANDELA UNIVERSITY

ACDI African Climate & Development Initiative

But also on a more "personal" scale

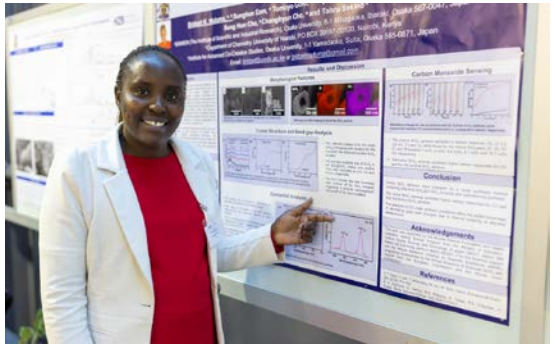
- Cooperations between researchers
- Cooperation between instutes
- Use of the Synchrotron Source
- Remote measurments of samples
- Internships
- PhD thesis
- Joint events*
- Support in career development

- Collaboration between Synchrotrons and users
- Beamline for Africa at SESAME
- Synchrotron for Africa

Exchange in both directions

*conferences and workshops: next year:Energy science@large scale facilities - Sustainability though collaboration - in June 2025in Nairobi

Synchrotrons as multi-purpose-multi-user facilities are large enough to bring people from many fields and many regions together



Curiosity driven research

Daniel Zajfmann:

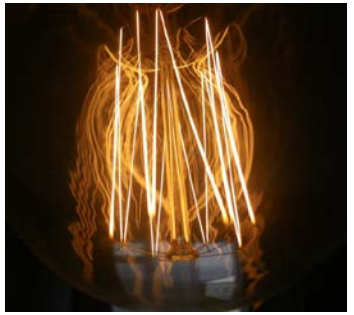
(…) If we would have been sitting here 200 and some years ago ... Well, of course there would be no projectors, no microphone, but also no light. And in any room that we would have been sitting, there would have been a lot of candles. About 200 years ago, actually mostly in the UK but also in Germany, there was a lot of R&D for candles. People were investing a lot of money to get better candles, producing more light, different colors, different perfume. (…)

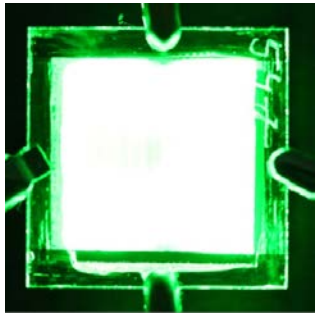
Then came this gentleman named Michael Faraday and he invented electricity. Now I want to remind you of something. It doesn't matter how much money you're going to invest in developing new candles - you will never get electricity.

The solution to your problem is not always where the problem is. (…)

https://www.youtube.com/watch?v=Os6ilKTK5KM&t=6m22s

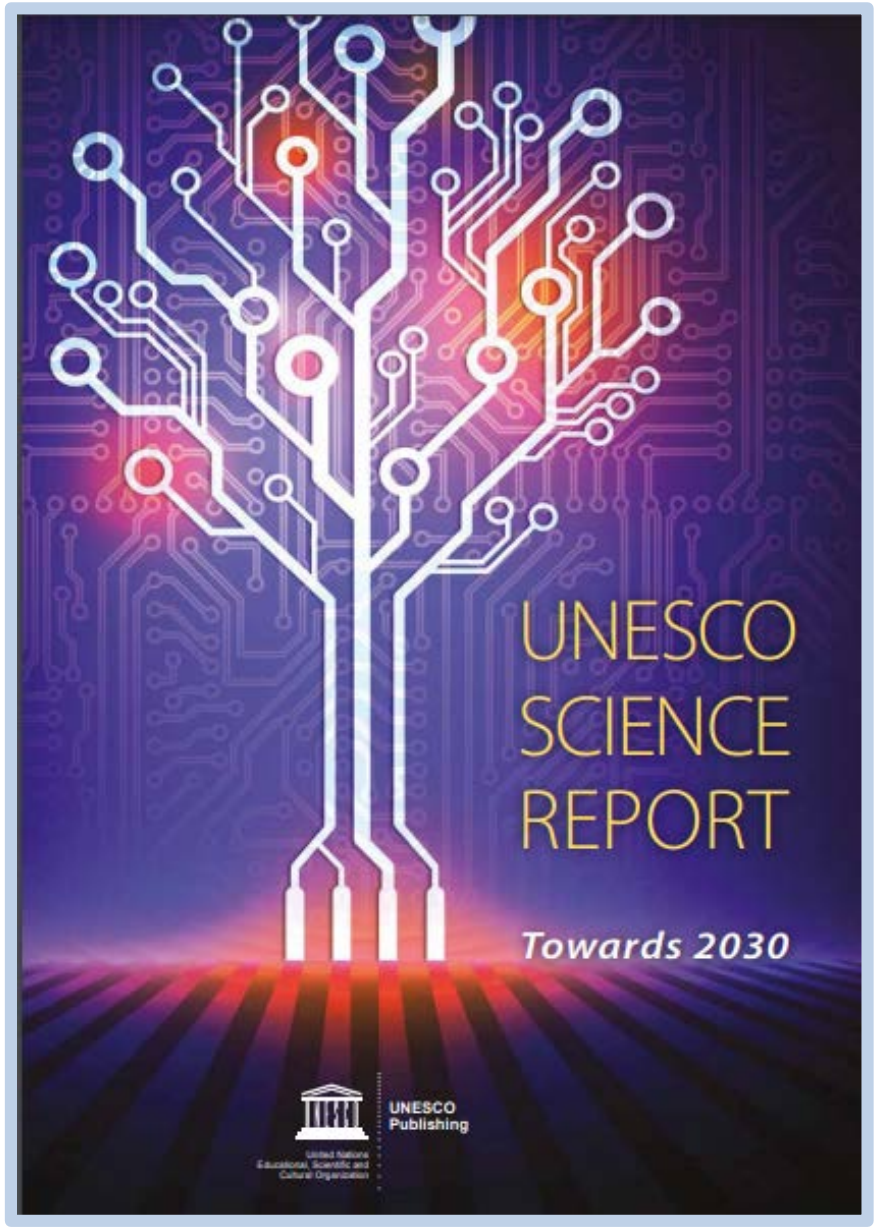
Therefore, it is even more important to include the whole world into the exchange of knowledge and ideas





Thank you for your kind attention

https://www.lindau-nobel.org/a-driving-force-towards-peace-scientific-cooperation/ Picture: iStock.com/Rawpixel Ltd



Contents

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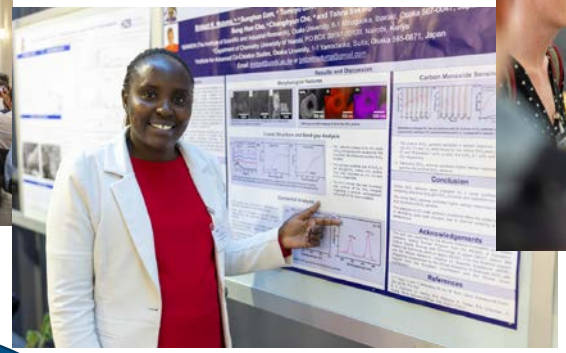
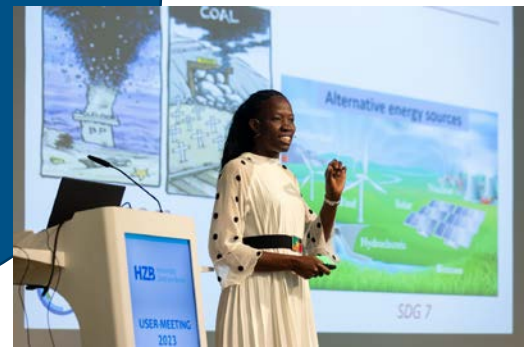
Let's change things to the better!



As scienetists we are ambassadors for knowledge, development, peaceful cooperation, solutions, and more



Together!

But what is Science Diplomacy in an increasingly fragmented and dangerous world?

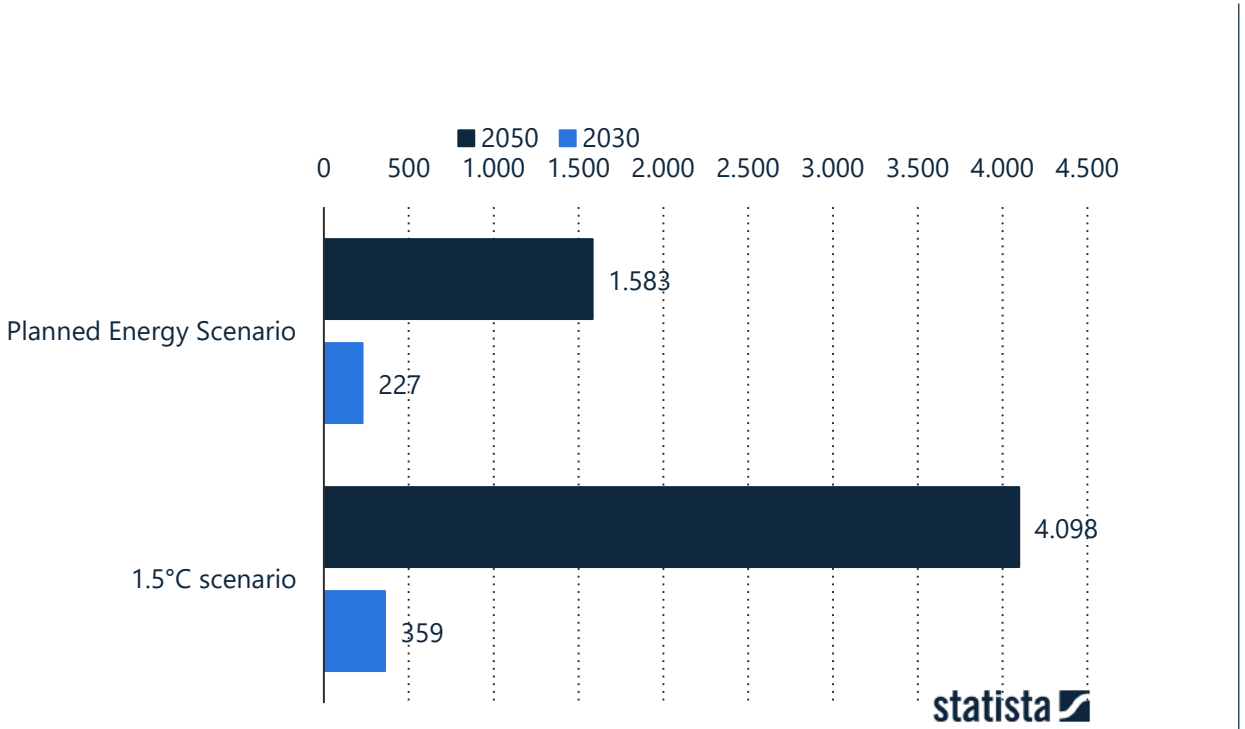
https://royalsociety.org/-/media/about-us/international/science-diplomacy/science-diplomacy-in-an-era-of-disruption.pdf

CONTENT

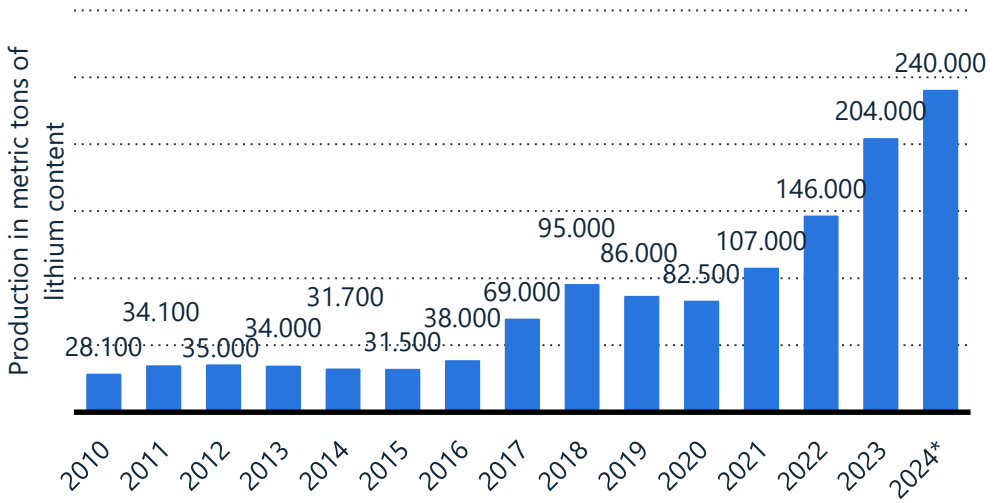
https://www.leaps-initiative.eu/wp-content/uploads/2024leaps_researchfordailylives-1.pdf

Global needs of battery storage capacity in power sector 2030-2050, by scenario

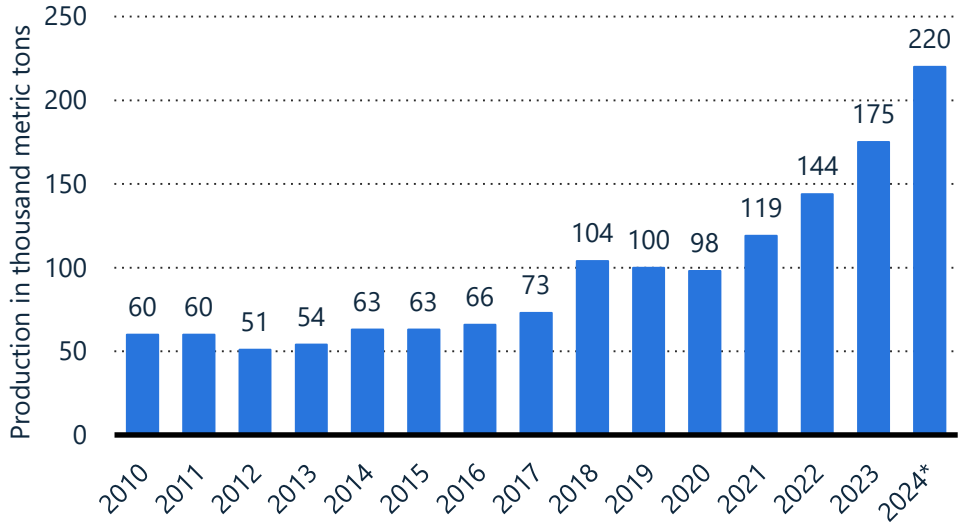
Capacity in gigawatts



Global lithium mine production 2010-2024



Cobalt mine production volume in the Democratic Republic of Congo 2010-2024



technology transfer and collaboration with Industry