Materials for Hybrid Energy Storage

Creating an Eco-System for Innovation

Expert Webinar April 14, 2021
10:00 AM – 12:00 PM (CET)

JP Energy Storage
Numbers and Figures

- Established in 2011
- 39 ROs and Universities
- 15 Member States/Associated Countries
- 6 Sub-Programmes
- 5 Energy Storage Technologies

JP Energy Storage

Mission and Vision

EERA
European Energy Research Alliance
Energy Storage

- developing **common research** and coordinating the scientific community
- establishing a **dialogue at European level** among all stakeholders involved in energy storage R&D
- facilitating **knowledge transfer** by communication with industry and stakeholders
- **advising policy makers** by identification of regulatory barriers and providing policy recommendations
- establishing **best practices** by developing new technologies and pave the way to market introduction

JP Energy Storage
Sub-Programmes

EERA European Energy Research Alliance
Energy Storage

- Five Sub-Programmes reflecting the five storage principles and one cross-cutting Sub-Programme dealing with techno-economic aspects and sustainability

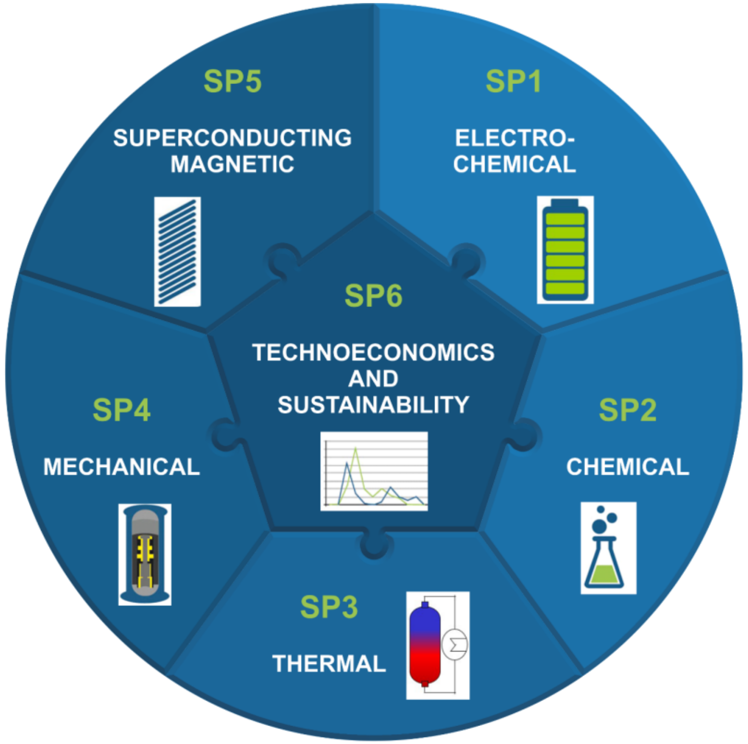
- New energy storage solutions are needed to meet
  - short-term (seconds and minutes)
  - medium-term (days and weeks)
  - long-term (seasonal)

  energy storage requirements for various energy carriers and provide valuable ancillary services to the energy system

- **StoRIES** proposal submitted in January 2021 (H2020 EGD call) - aiming at creating a Storage Research Infrastructure Eco-System in Europe, if funded.

StoRIES

More info at www.eera-energystorage.eu/stories



Webinar on Materials for Hybrid Energy Storage

Setting the scene

- December 2019 - The European Commission presented the “**European Green Deal**”, a set of policy initiatives aiming at ensuring the EU becomes climate neutral by 2050.

- Strong implications for the energy sector - New energy storage solutions are needed for:
    - suppling more flexibility and balance in the grid
    - providing a back-up to intermittent renewable energy
    - contributing to seasonal energy storage

- The challenges can be faced by innovative hybrid energy storage materials, devices and systems that combine existing and new solutions

- Need to create an **energy storage eco-system** enabling innovation in materials for hybrid energy storage

- This webinar aims at discussing potential collaboration and best way forward to create an active and persistent eco-system bringing together material science researchers, industry and policy makers

Webinar on Materials for Hybrid Energy Storage

Objectives

- To identify the needs for new energy storage materials from an industrial perspective
- To discuss how analytical facilities (e.g. synchrotrons) can support material acceleration platforms (MAPs) by improving the understanding of materials features
- To strengthen computational efforts to design and develop new functional materials for energy applications supported by AI measures
- To underline the importance of materials science in the future energy research for achieving the Clean Energy Transition
- To foster international cooperation and multidisciplinary interaction

Webinar on Materials for Hybrid Energy Storage

Agenda

TIME	
10:00	**Welcome and objectives of the meeting** Myriam Gil Bardají, KIT & EERA JP ES
10:15	**I-Hybrid Energy Storage Systems – Needs for new materials** Magdalena Graczyk-Zajac, EnBW (DE)
10:30	**II- Synchrotrons - A gateway to novel materials and international collaboration** Antje Vollmer, Helmholtz Zentrum Berlin (DE)
10:45	**III- Thinkable pathways for bridging energy materials simulations to synchrotron experiments** Süleyman Er, DIFFER (NL)
11:00	**IV- Cooperation and ways forward – The Clean Energy Transition Partnership** Nikolas Reschen, Federal Ministry Republic of Austria (AT)
11:15	**Round table**
11:45	**Questions from the audience**
12:00	**End of meeting**

Webinar on Materials for Hybrid Energy Storage

Speakers

Magdalena Graczyk-Zajac

Energie Baden-Württemberg (DE)

Project Leader R&D Technology Innovation

Focus: electrochemical storage solutions for stationary applications

Antje Vollmer

Helmholtz Zentrum Berlin (DE)

Beamtime Manager

Focus: supporting excellent science as well as promoting international cooperation to address global challenges

Süleyman Er

DIFFER (NL)

Research Group Leader

Focus: quantum calculations, artificial intelligence methods and advanced data-infrastructures

Nikolas Reschen

Austrian Federal Ministry (AT)

Policy Officer

Focus: climate action, environment, energy, mobility, innovation and technology

Materials for Hybrid Energy Storage

Dr. Magdalena Graczyk-Zajac, EnBW

14 April 2021

Agenda

1. EnBW AG: who we are and what we do
2. Electrical energy storage technologies
3. Hybrid energy storage: state-of-the-art and future

Agenda

1. **EnBW AG: who we are and what we do**
2. Electrical energy storage technologies
3. Hybrid energy storage: state-of-the-art and future

Who we are and what we do

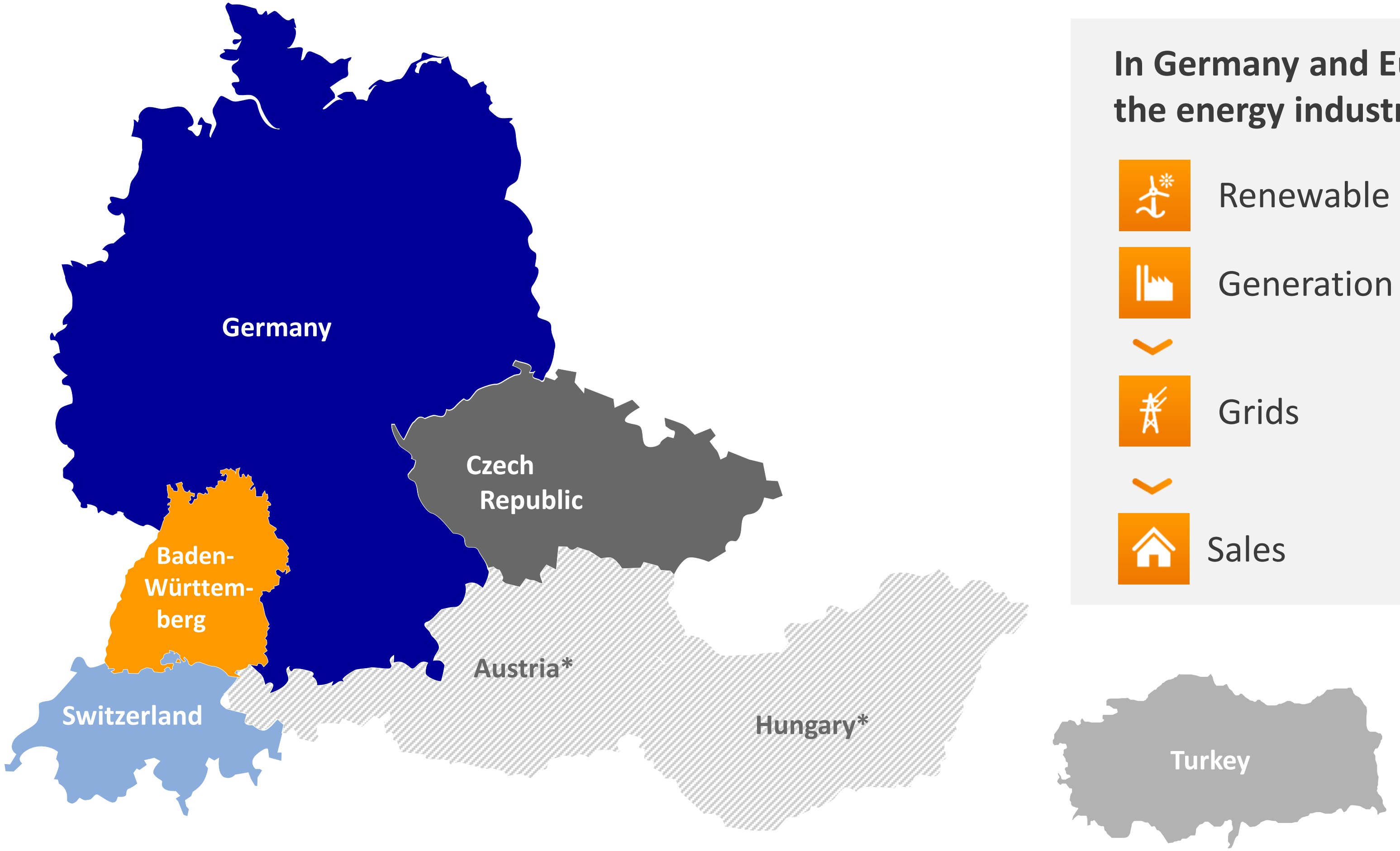
One of the **largest energy supply companies** in Germany and Europe, with **strong roots in Baden-Württemberg.** Our core business: **electricity, gas, heat and water.**

Our business segments

- We are vigorously expanding **renewable energies**.
- We transport electricity, gas and water across all voltage and pressure levels via our **grids**.
- Our **sales department** serves as contact for all energy-related issues of our customers.
- In the **trade and generation** segment we optimise our conventional power plants in terms of economy and CO_2 and trade energy for our customers and ourselves on the stock exchange.

We are evolving **from an energy provider to an infrastructure partner.**

EnBW in Europe

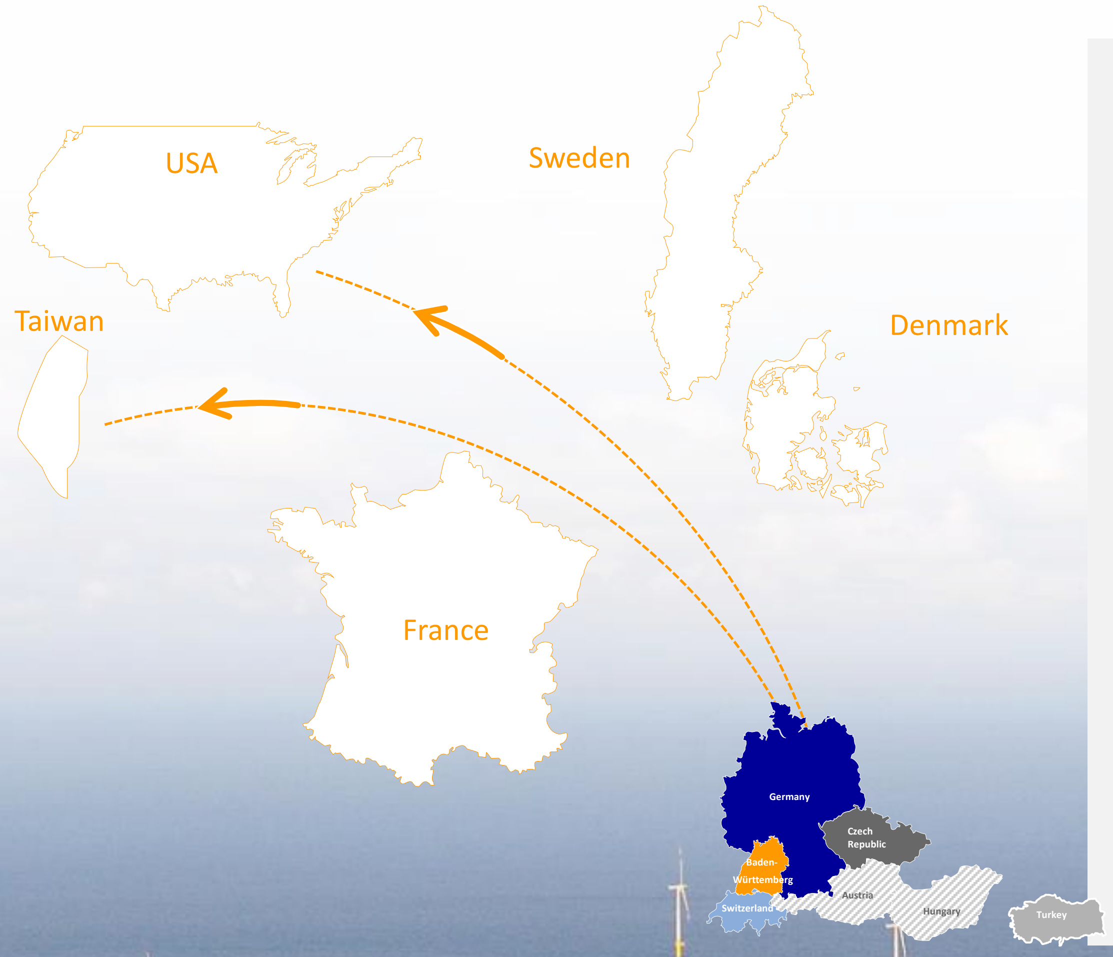


In Germany and Europe we operate in all stages of the energy industry value chain.

- Renewable Energies
- Generation and Trading
- Grids
- Sales

* Shares in different companies indirectly via EnBW Trust e. V.

Selective internationalisation in the field of renewable energies



From our base in Baden-Württemberg we capture new growth fields in international markets.

Examples

- Turkey: hydropower, onshore wind energy, photovoltaics; installed output: 495 MW
- Sweden: onshore wind energy, installed output: >100 MW
- USA: establishment of a national subsidiary and of representative offices in different regions; development partnership to build floating foundations for offshore wind power
- France: establishment of a representative office and start of project development
- Taiwan: establishment and building of EnBW Asia Pacific Ltd. and development of offshore projects with local partnersDenmark: expansion of the service range to companies specialising in the maintenance and repowering of wind power plants

Brands and shareholdings at home and abroad

EnBW

Baden-Württemberg

EnBW

NetCom BW

Netze BW

EnBW ODR

terranets bw

TRANSNET BW

GVS GasVersorgung Süddeutschland

ZEAG energie

Erdgas Südwest

NaturEnergie Plus

34 shareholdings in municipal utilities
50 leased grid companies

Germany

VNG

yello

Stadtwerke Düsseldorf

SENEC

Sales & Solutions

plusnet

Internationally

Turkey — BORUSAN, EnBW Enerji Ortaklığı

Switzerland — EnergieDienst

Czech Republic — PRE

Denmark — CONNECTED WIND SERVICES

Sweden — EnBW Sverige AB

France — VALECO

Asia — EnBW Asia Pacific 安能亞太有限公司

USA — EnBW North America

Agenda

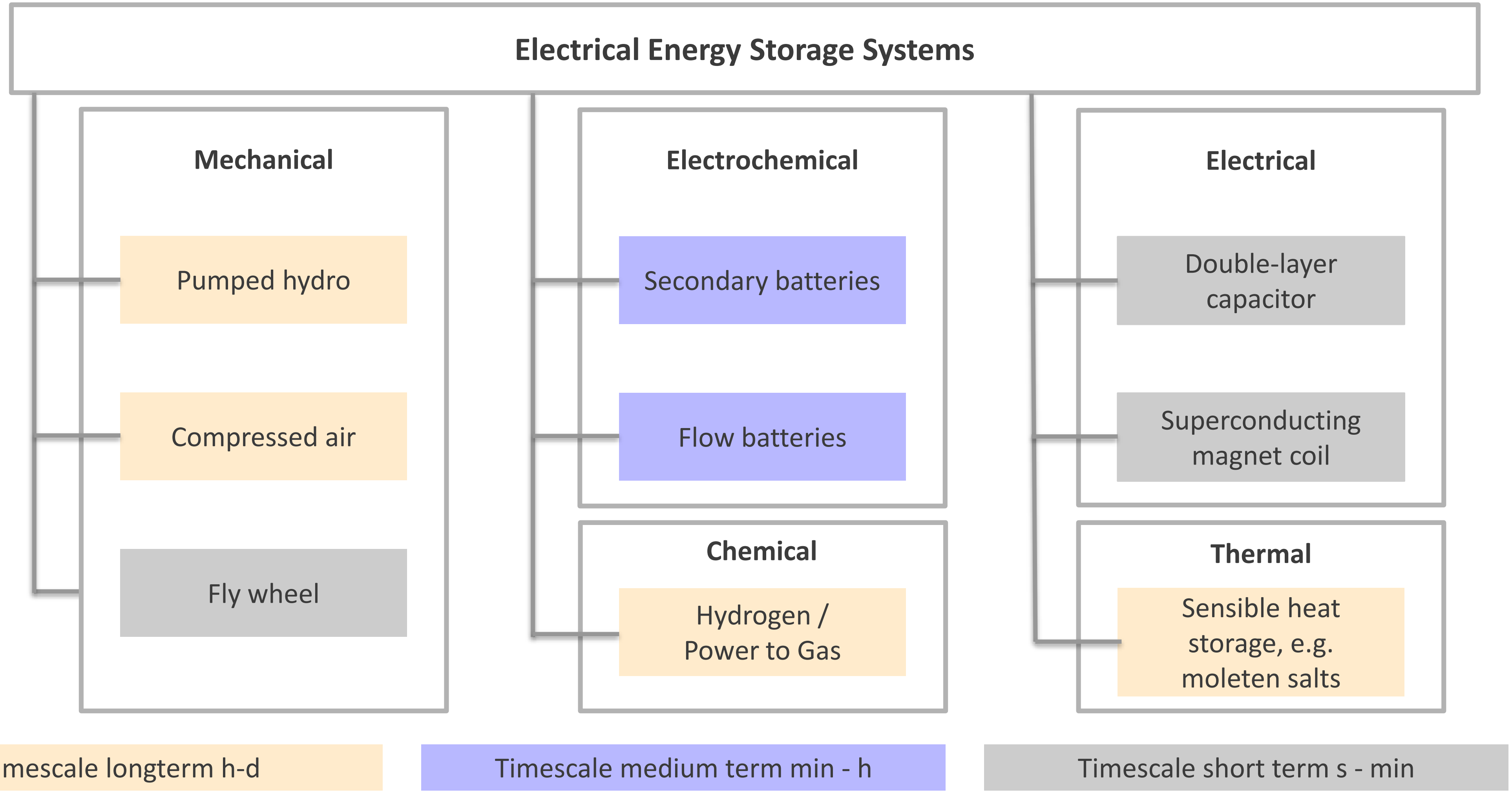
EnBW

1 EnBW AG: who we are

2 **Electrical energy storage technologies**

3 Hybrid energy storage: state-of-the-art and future

Electrical energy storage technologies



Redrawn from Energy Storage in Power Systems (2016) Chapter 4, 2016 John Wiley & Sons

Electrical energy storage technologies

Energy Storage System	El. Chemical				Mechanical				El.		Ch.
APM	Lead-Acid	NaS	Li-Ion	Redox-Flow	Pumped Hydro	FES	CAES	AA-CEAS	DLC	SMES	H_2
Black Start Capacity	**	**	**	**	***	*	***	***	*	*	*
Energy Market Participation	***	***	***	***	**	*	**	**	*	*	*
Grid Quality	**	***	***	**	*	**	***	***	*	*	*
Island Operation	***	***	***	***	*	*	**	**	*	*	*
Peak and Load-Shaving Services	***	***	***	**	***	*	***	***	*	*	*
Primary Control Reserve	***	***	***	**	***	*	***	***	*	*	*
Residential Home Storage	***	*	***	**	*	*	*	*	*	*	*
Secondary Control Reserve	**	***	***	**	***	*	**	***	*	*	*
Tertiary Control Reserve	**	**	***	**	*	**	*	*	*	*	**

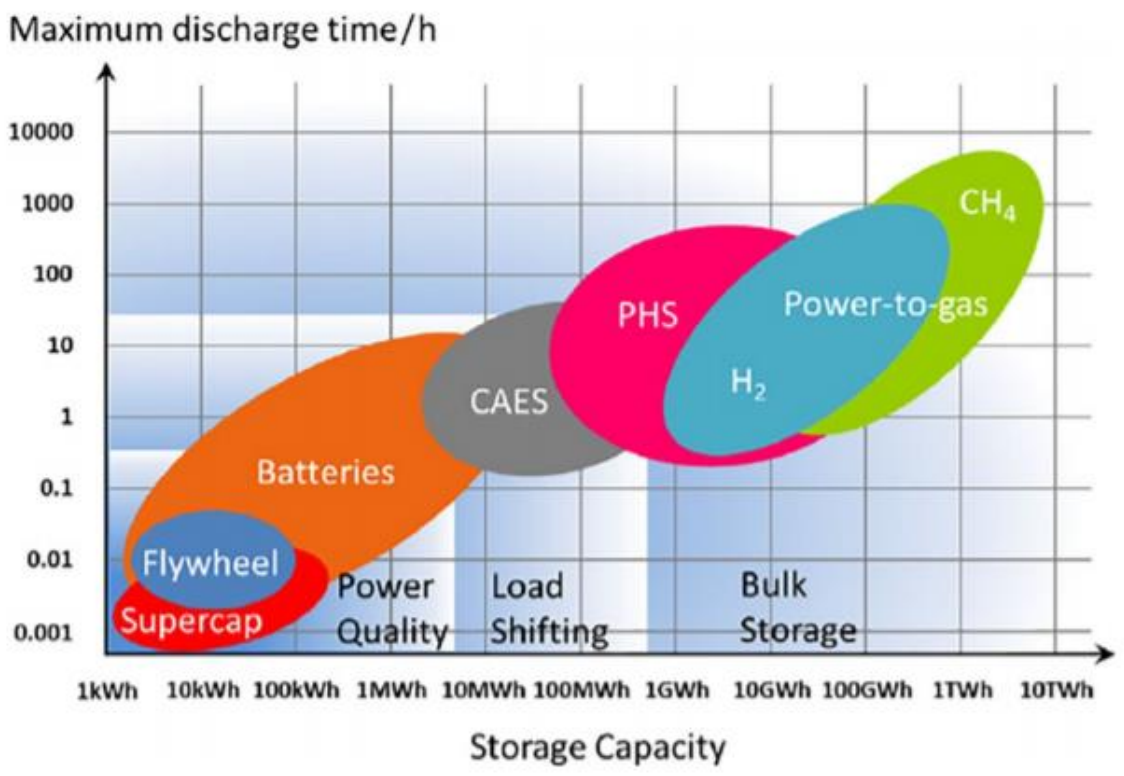
Battery Energy Storage Systems have high ability to serve a specific applications modes

Stationary Lithium-Ion Battery Energy Storage Systems A Multi-Purpose Technology (2017) Marcus Müller PhD TU München
https://onlinelibrary.wiley.com/doi/pdf/10.1002/ente.201600609

Electrical energy storage technologies

Energy Storage System / APM	El. Chemical				Mechanical				El.		Ch.
	Lead-Acid	NaS	Li-Ion	Redox-Flow	Pumped Hydro	FES	CAES	AA-CEAS	DLC	SMES	H_2
Black Start Capacity	**	**	**	**	***	*	***	***	*	*	*
Energy Market Participation	***	***	***	***	**	*	**	**	*	*	*
Grid Quality	**	***	***	**	*	**	***	***	*	*	*
Island Operation	***	***	***	***	*	*	**	**	*	*	*
Peak and Load-Shaving Services	***	***	***	**	***	*	***	***	*	*	*
Primary Control Reserve	***	***	***	**	***	*	***	***	*	*	*
Residential Home Storage	***	*	***	**	*	*	*	*	*	*	*
Secondary Control Reserve	**	***	***	**	***	*	**	***	*	*	*
Tertiary Control Reserve	**	**	***	**	*	**	*	*	*	*	**

Battery Energy Storage Systems have high ability to serve a specific applications modes



But … Battery Energy Storage solely covers only a part of time- and capacity scale

Stationary Lithium-Ion Battery Energy Storage Systems A Multi-Purpose Technology (2017) Marcus Müller PhD TU München
https://onlinelibrary.wiley.com/doi/pdf/10.1002/ente.201600609

Stationary storage with solar parks

Solarparks Weesow-Willmersdorf, Alttrebbin and Gottesgabe: 500 MW

- Generation of environmentally friendly electricity for more than 140,000 households
- 325,000 tonnes of CO_2 saved thanks to solar energy
- Construction site of around 400 hectares, fully greened with native seeds; trees, hedgerows and bushes will be planted in the immediate vicinity. Sheep are to graze in these large-scale projects.
- EnBW aims to produce around half of its power using renewable energy sources by 2025
- Battery storage solution planned together with PV Parks

https://www.enbw.com/media/presse/docs/dokumente-zu-pressemitteilungen/2020/20201203_pm_die_enbw_treibt_den_ausbau_der_solarenergie_voran_1.pdf

Reallabor H2-Wyhlen: Green Hydrogen from Upper Rhine

Power-to-Gas plant in Grenzach-Wyhlen on the Upper Rhine produces hydrogen by means of electrolysis.

Electricity for H_2 production comes from the neighbouring hydroelectric power plant.

- Research funding of approximately 13.5 Mio €
- Largest power-to-gas plant in southern Germany
- Goal: expanding the existing PtG plant in by 5 MW of electrical output to supply local transport with green H_2 and to use it in industrial sectors.
- The waste heat generated during electrolysis is to be used to heat residential in the surrounding area.

MESSER Gases for Life | ZSW | DIALOGIK | DSM

https://www.energiedienst.de/produktion/wasserstoff/reallabor-h2-wyhlen/

https://youtu.be/16X8mOG6bdQ

Agenda

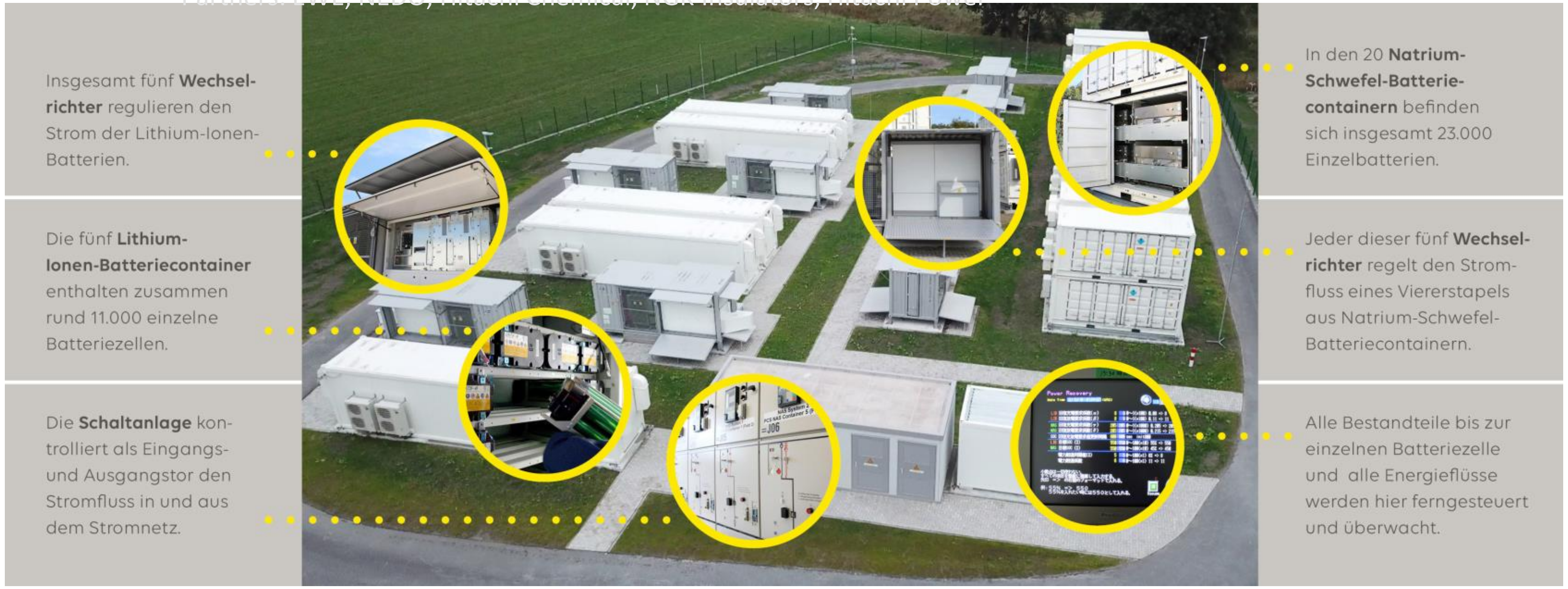
1 EnBW AG: who we are

2 Electrical energy storage technologies

3 **Hybrid energy storage: state-of-the-art and future**

Hybrid storage system in Varel: Na-S + LiB
„energy revolution storage system”

Partners: EWE, NEDO, Hitachi Chemical, NGK Insulators, Hitachi Power



Two proven battery types intelligently managed together:

- 2.9 MWh, 7.5 MW of Lithium-ion batteries, which enable quick access to the energy stored
- 20 MWh, 4.4 MW NaS batteries, suited to the more long-term interim storage of larger capacities

The system aims to balance out frequency fluctuations, thereby contributing to the stability of the network.

If necessary, it can feed 11.5 MW of output into the electricity network or draw from it.

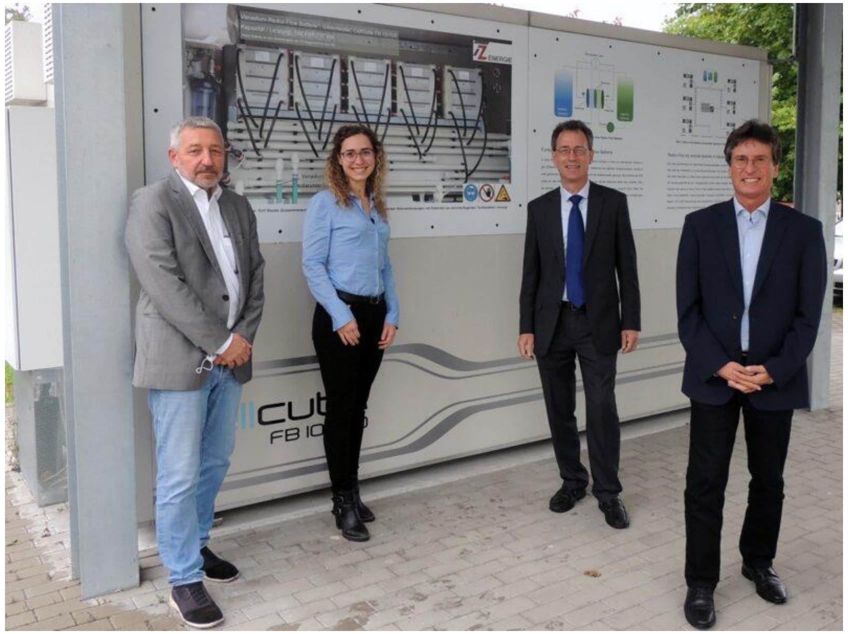
Its storage capacity is enough to supply every household in Varel with electricity for five hours.

https://www.ewe.com/en/media/press-releases/2018/11/intelligent-large-scale-battery-officially-commences-operation-in-varel-ewe-ag

https://www.youtube.com/watch?v=GTo7RCpAUQg

EU-Projekt HyFlow

EnBW



Coordinated by Hochschule Landshut, Grant Agreement 963550

LC-BAT-9-2020: Hybridisation of battery systems for stationary energy storage

HyFlow

- Designs and develops an optimized HESS consisting of a vanadium redox flow battery (VRFB), a supercapacitor (SC), an advanced converter topologies and a highly flexible control system that allows adaptation to a variety of system environments
- The system enables modular long-term energy storage through VRFB, while the SC as a power component ensures high load demands
- Energy Management System (EMS) will be designed to perfc high level of control and adaptability

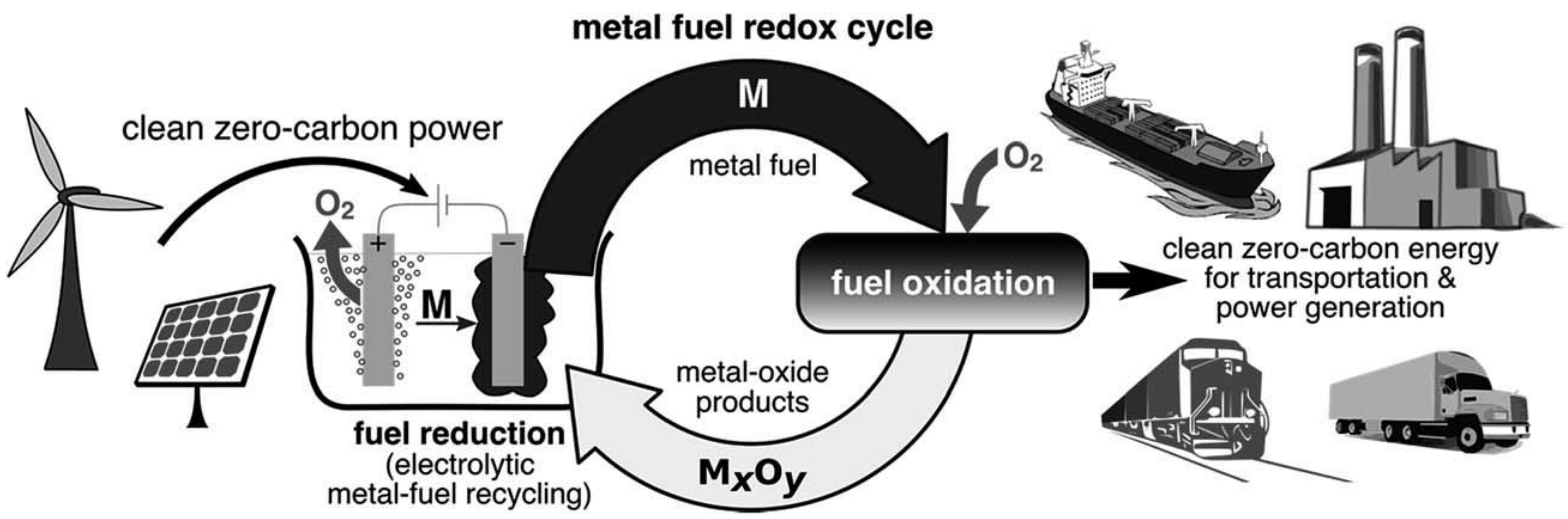
HyFlow
HYBRID ENERGY STORAGE SYSTEM

https://www.solarserver.de/2021/01/22/hybrid-energiespeicher-aus-redox-flow-batterie-und-superkondensator/

https://cordis.europa.eu/project/id/963550/de

Possible future solutions: Seasonal storage in reactive metals

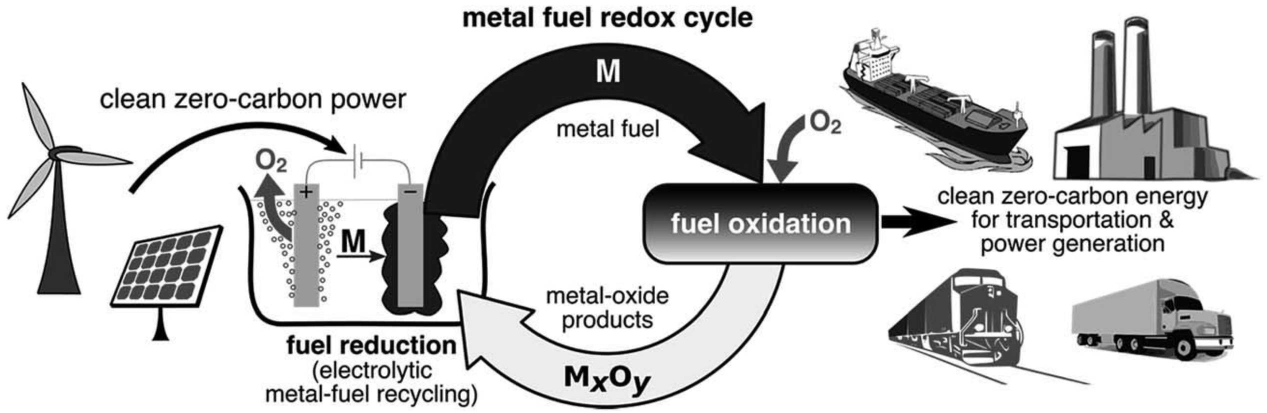
Power-to-Metal: Al, Zn, Ca



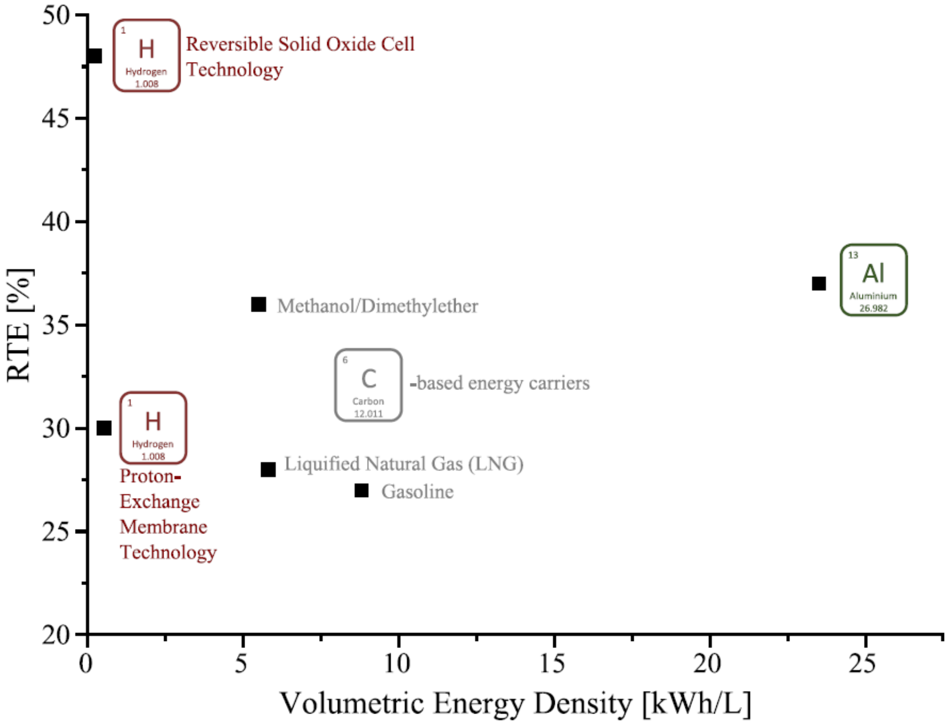
P. Julien, J. M. Bergthorson, Sustainable Energy Fuels (2017) 1, 615.

Possible future solutions: Seasonal storage in reactive metals

Power-to-Metal: Al, Zn, Ca



Aluminium offers many advantages as energy storage, but RTE could be improved



Electrochemical conversion (i.e., the direct transformation of Chemica Energy into Electrical Energy) is much more efficient than conversion through heat generation

P. Julien, J. M. Bergthorson, Sustainable Energy Fuels (2017) 1, 615.
D. J. Durbin and C. Malardier-Jugroot, Int. J. Hydrogen Energy (2013) 38, 14595–14617.
L. Barelli et al., Energy Technology (2020) 2000233, DOI: 10.1002/ente.202000233
M. Baumann, L. Barelli, S. Passerini Adv. Energy Mater. 2020, 10, 2001002

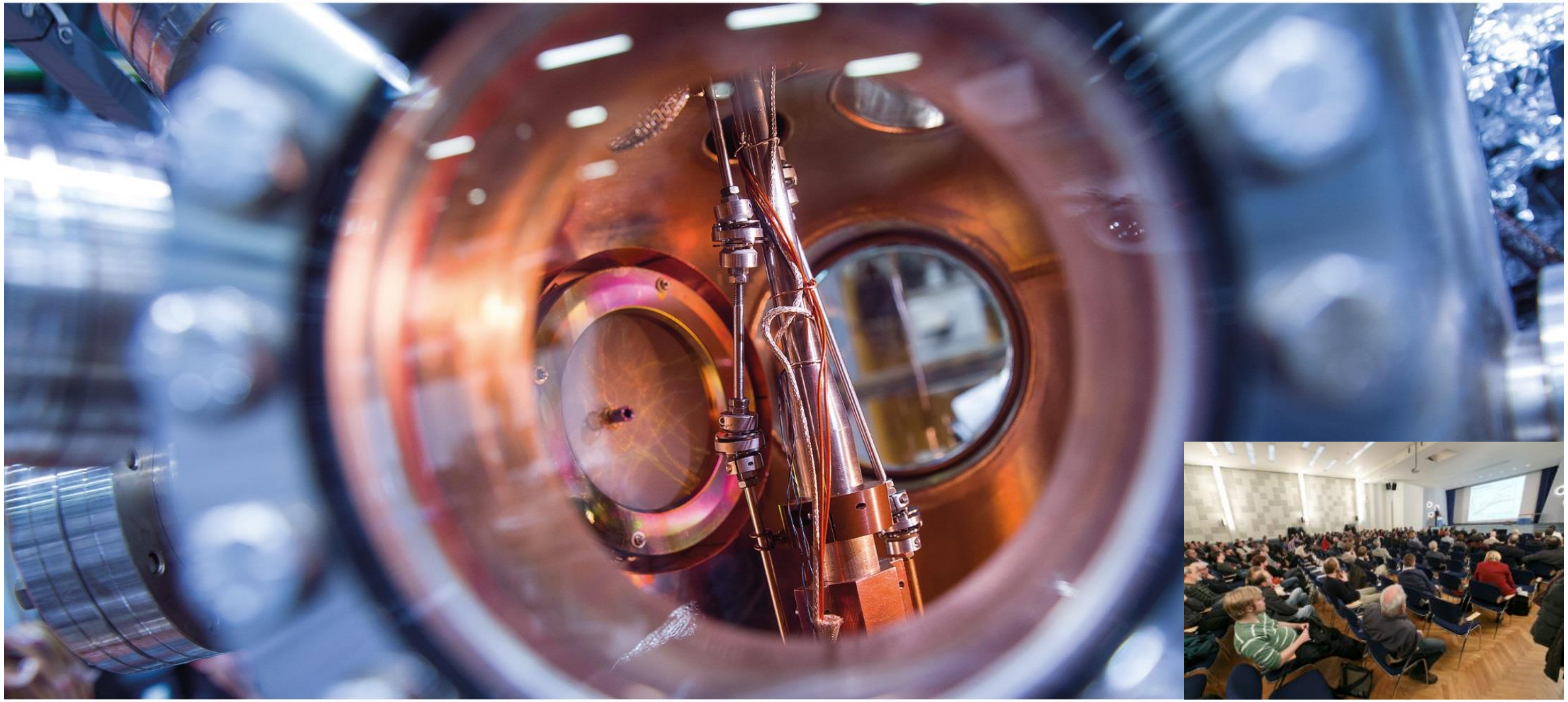
Take-home message

- There is no single universal energy storage solution that is ideal for every grid-scale application
- The commercially available stationary storage solution aim short- and medium-term time scale
- Hybrid energy storage systems are the future of the stationary storage
- Material development required for:
  - Improvement of short- and medium-term battery storage solution
  - Developing safer and “storable” materials for a long-term (seasonal) energy storage

Thank you for your attention!

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

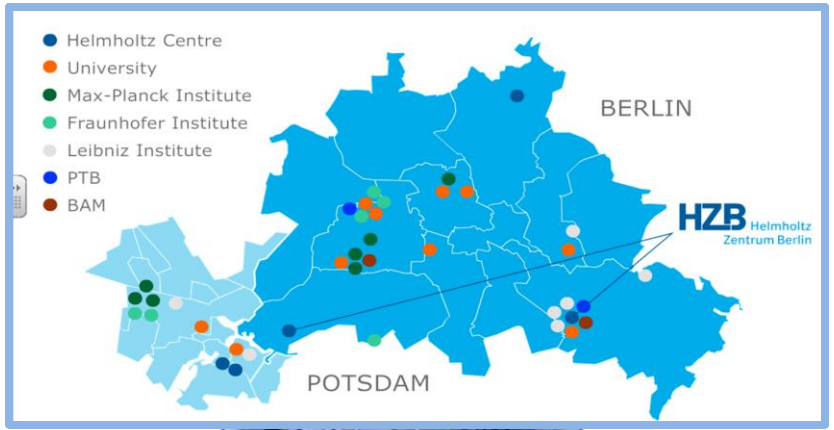
HZB Helmholtz Zentrum Berlin

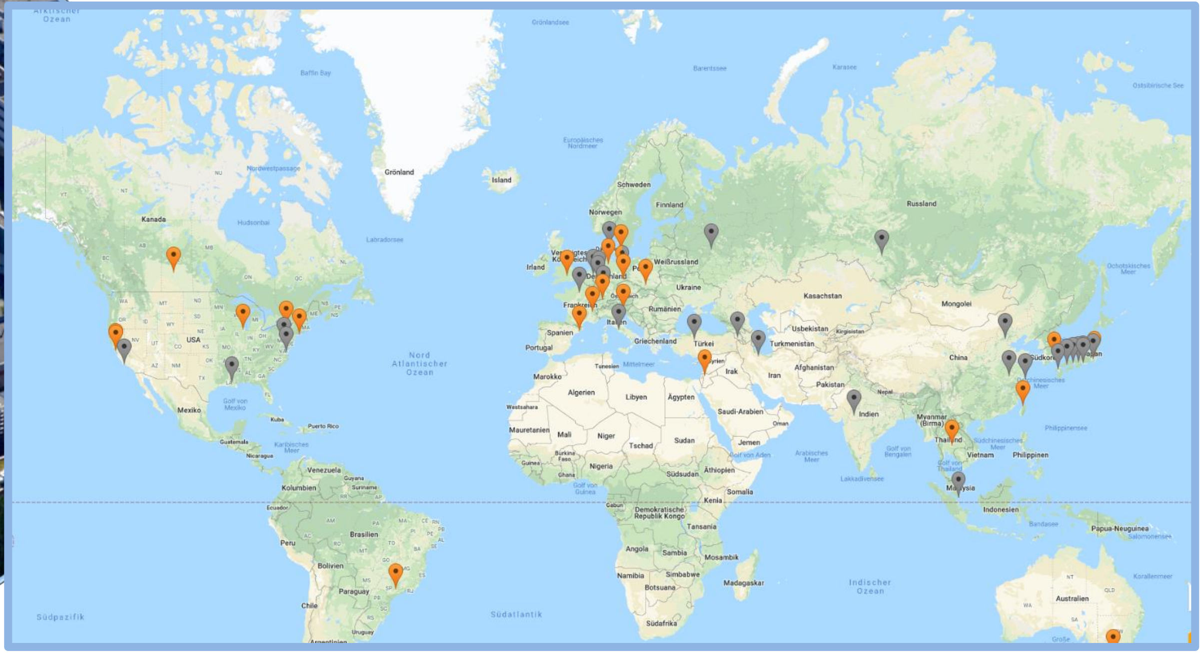


SYNCHROTRONS: A GATEWAY TO NOVEL MATERIALS AND INTERNATIONAL COLLABORATION

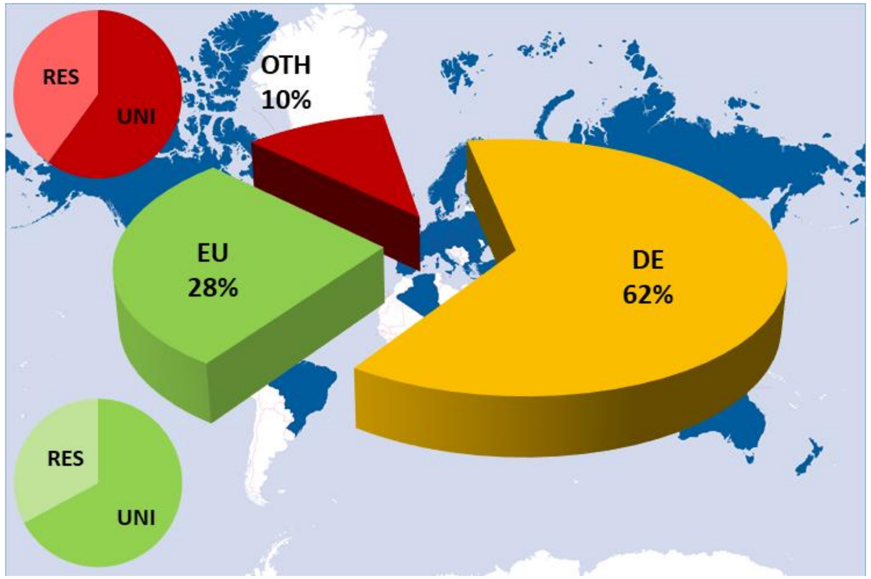
Antje Vollmer

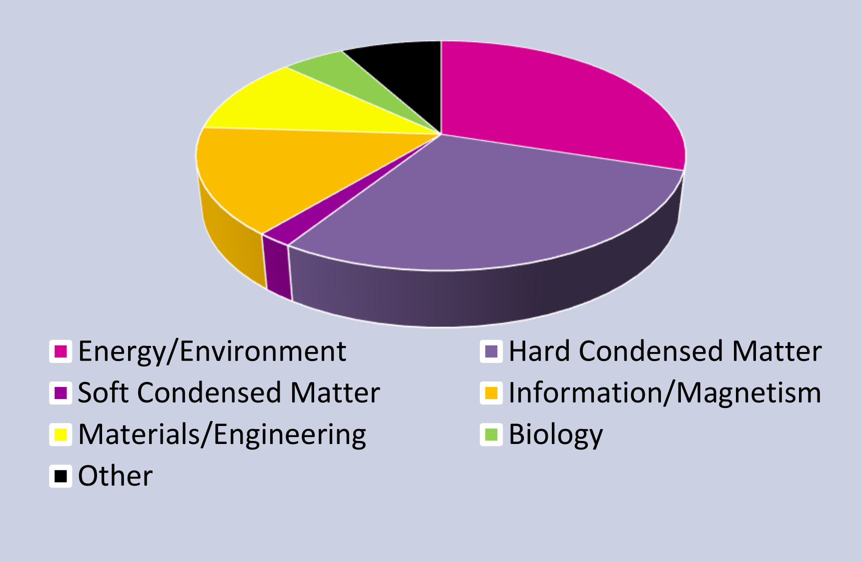
Synchrotrons of the World





Example BESSY II





BESSY II Average numbers:
- More than 1200 proposals per year
- About 800 beamtime campagnes
- More than 3000 user visits
- More than 10000 registered users
- 12000 overnight stays in the guesthouse

Publications
More than 500 (verified) peer reviewed publications per year from 27 simultaneously operating beamlines.

Broad variety of research fields
30% of proposals with energy-related topics

European Union:

More than 270 Beamlines

More than 6000 beamtime campaigns

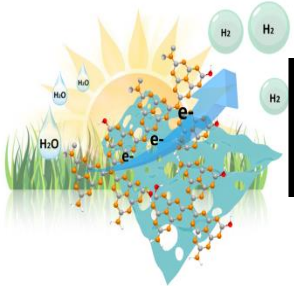
More than 30.000 users

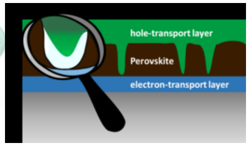
More than 5000 publications

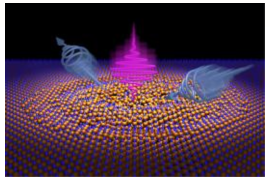
BESSY II– Multitude Of Users And Research Fields

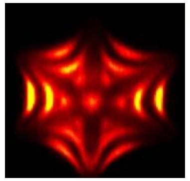
HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

HZB Helmholtz Zentrum Berlin





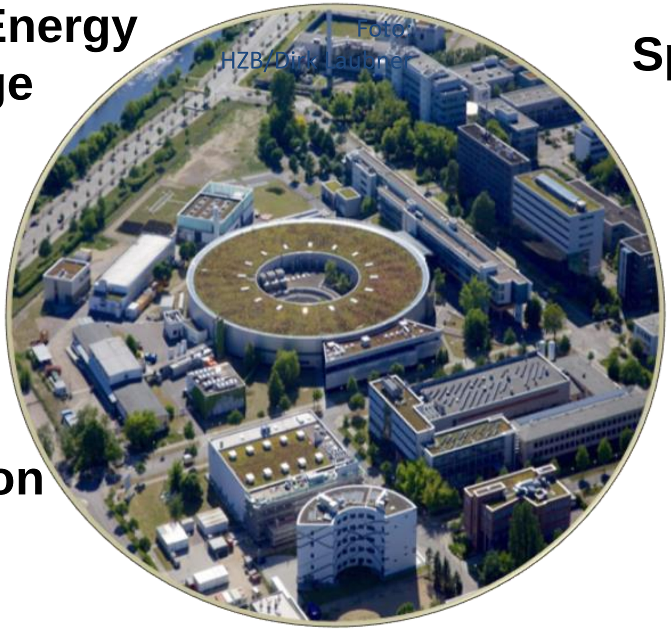




Physics

Energy & Energy Storage

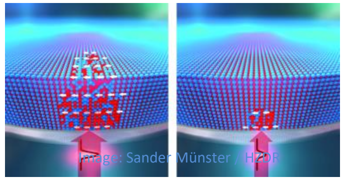
Space



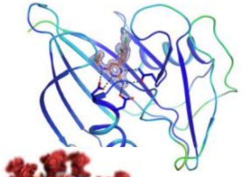
Metrology

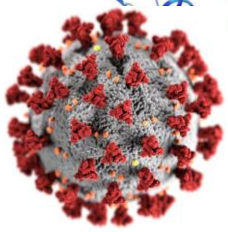
Cultural Heritage

Information



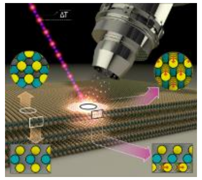
Medicine & Biology

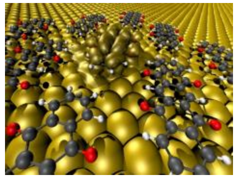




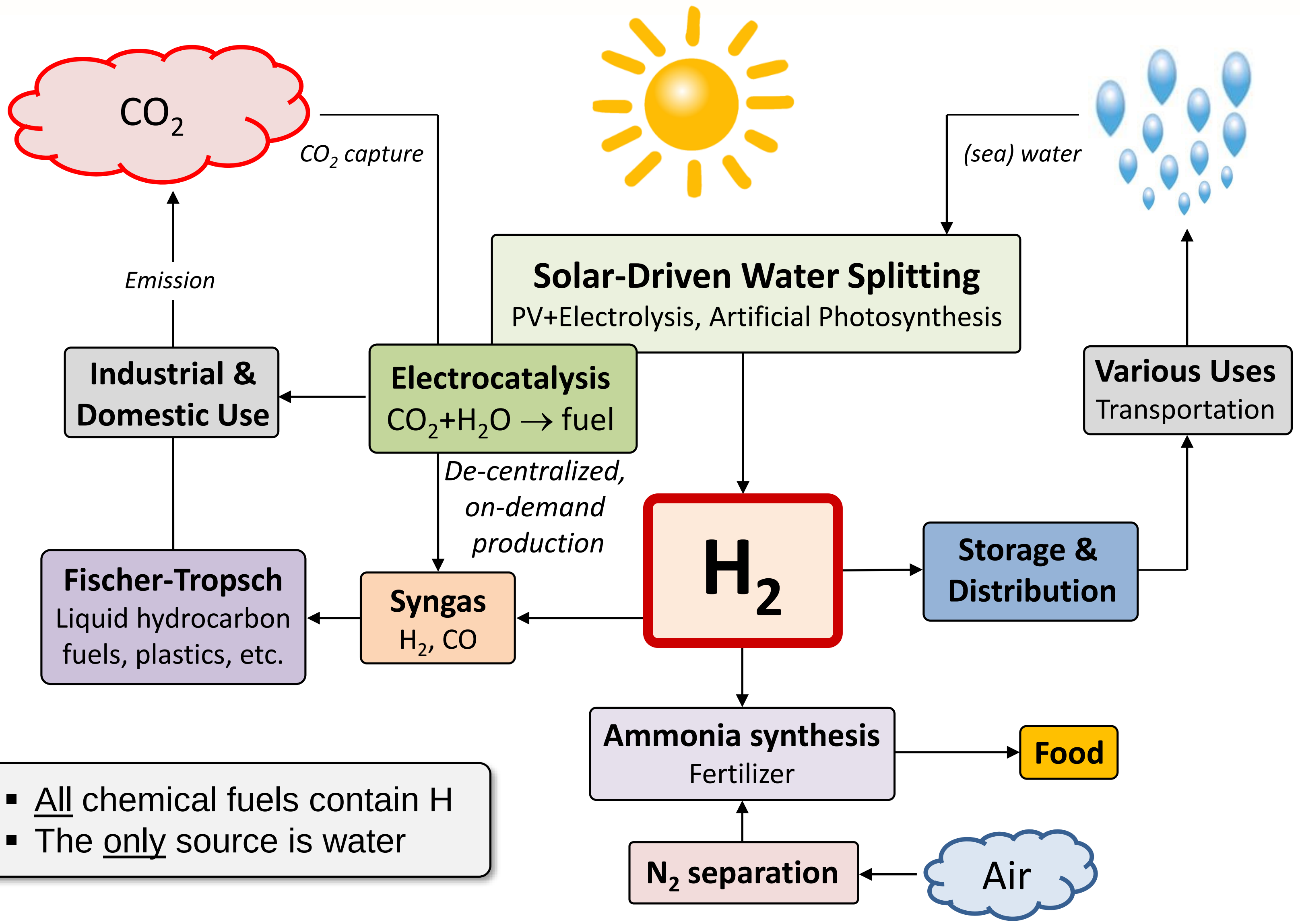
Environment

Chemistry & Catalysis





Central Role of Hydrogen in a Fossil Fuel-Free Society



- All chemical fuels contain H
- The only source is water

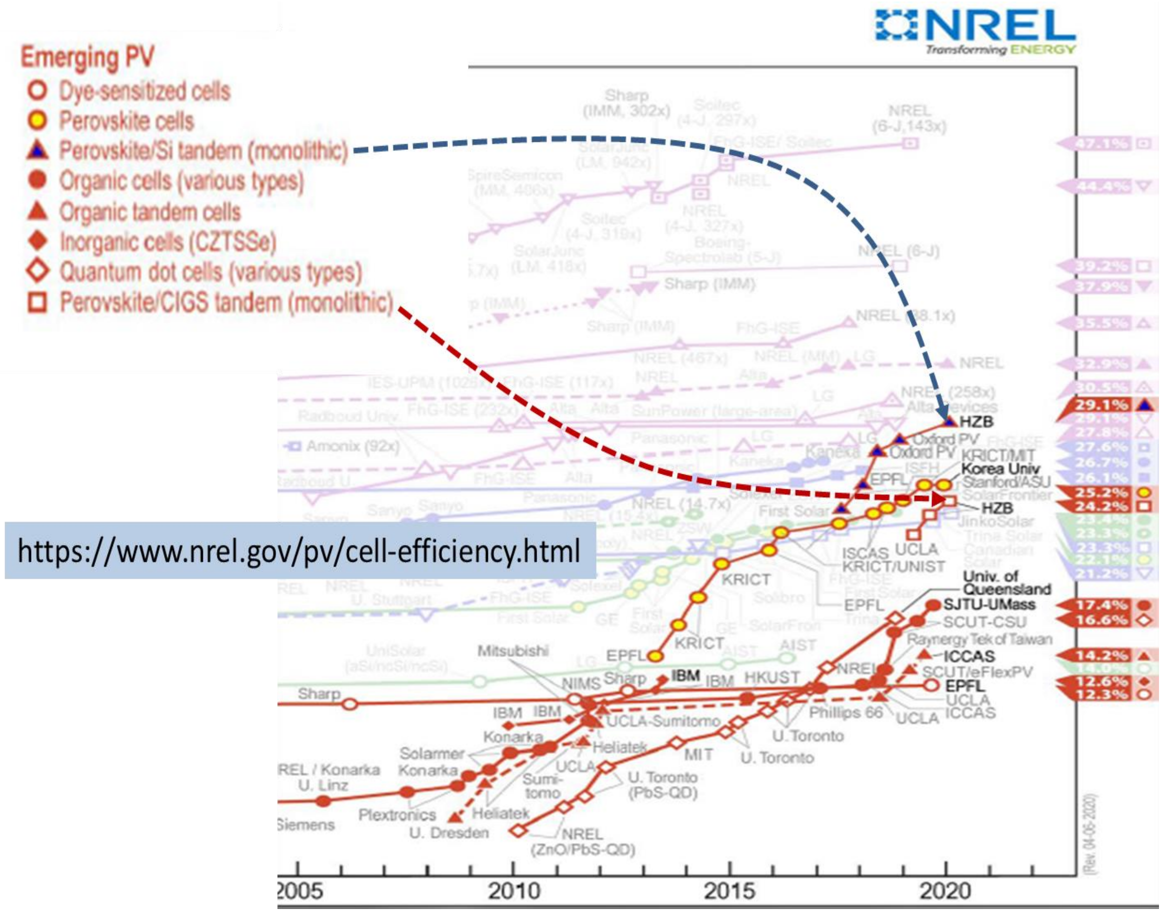
MRS Energy Sustain. 4, E13 (2017)

SUSTAINABLE ENERGY - CLIMATE – ENVIRONMENT - INFORMATION TECHNOLOGY – HEALTH

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.

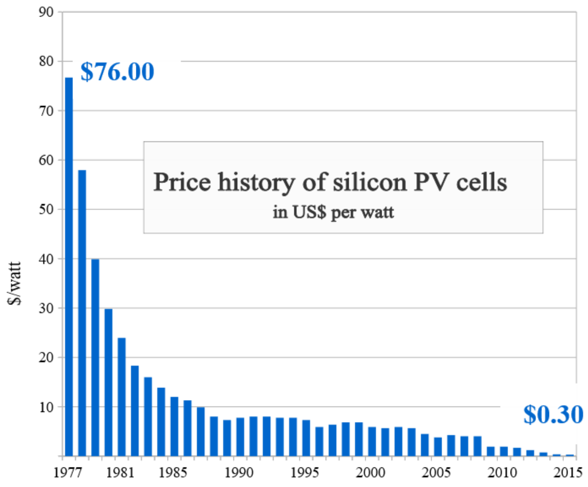
22m²
Of solar panels cover the need of an average household



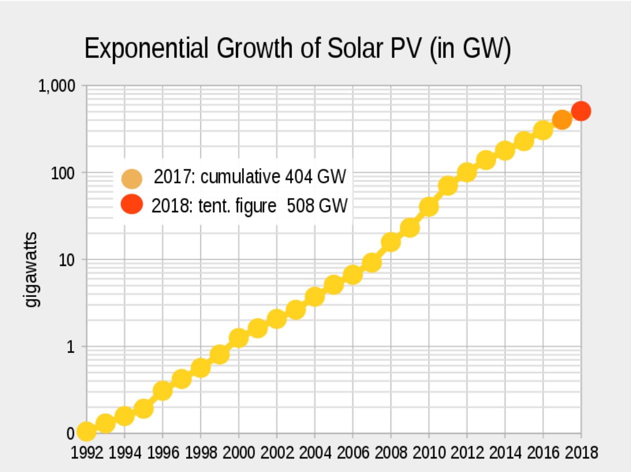
https://www.nrel.gov/pv/cell-efficiency.html

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

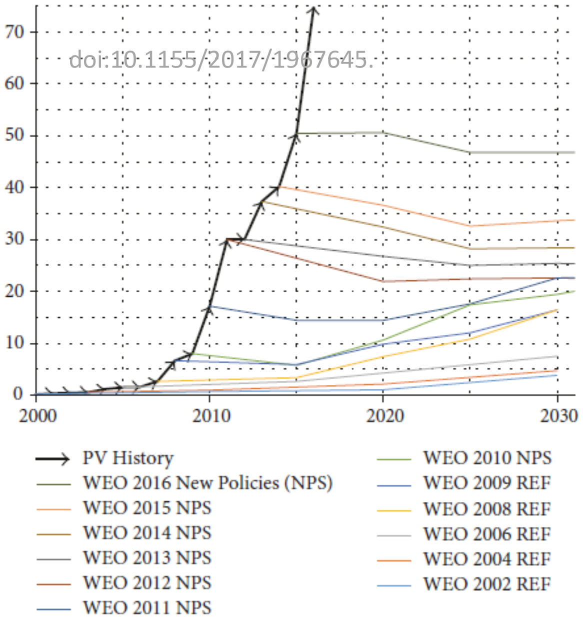
Mission Accomplished?

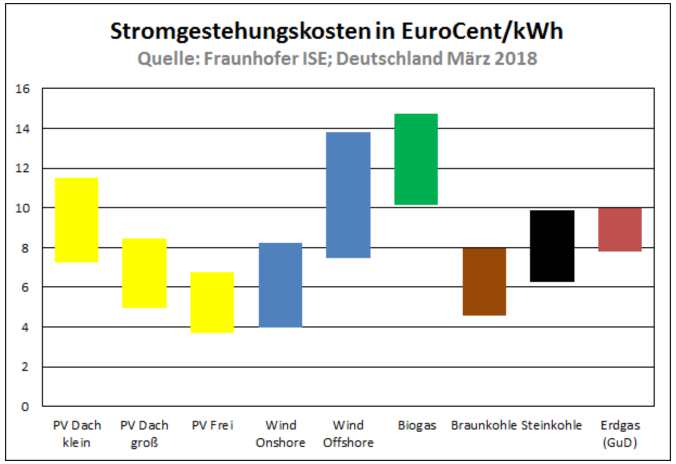


Source: Bloomberg New Energy Finance & pv.energytrend.com



https://commons.wikimedia.org/w/index.php?curid=36675622

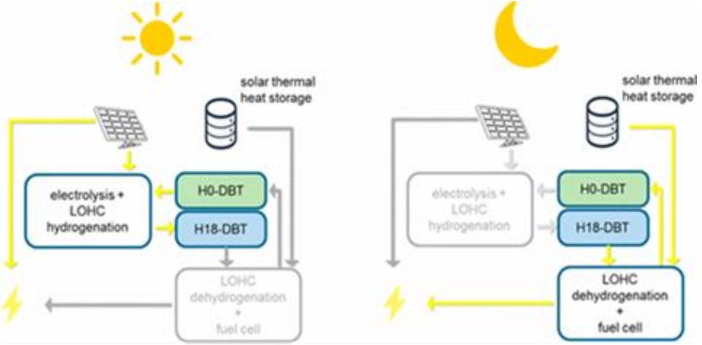




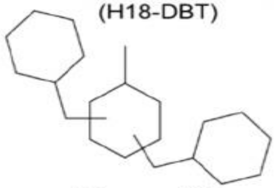
HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

HZB Helmholtz Zentrum Berlin

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



perhydro dibenzyltoluene (H18-DBT)



6.2 mass% H_2
(2.05 kWh/kg LOHC)

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.

Hydrogenious LOHC Technologies GmbH

- 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.

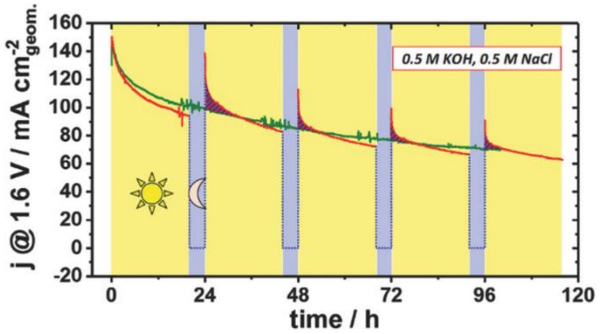
Acc. Chem. Res., 2017, 50 (1), pp 74–85,doi:10.1021/acs.accounts.6b00474, BESSY II Instrument UE56/2 and U49

FAU Erlangen

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

HZB Helmholtz Zentrum Berlin

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 (red) mimicking a 4 h night cycle

Seawater electrolysis faces fundamental chemical challenges

Current technologies focusing on splitting water into oxygen and hydrogen (H_2O + energy → ½O_2 + H_2) to use hydrogen as energy carrier .

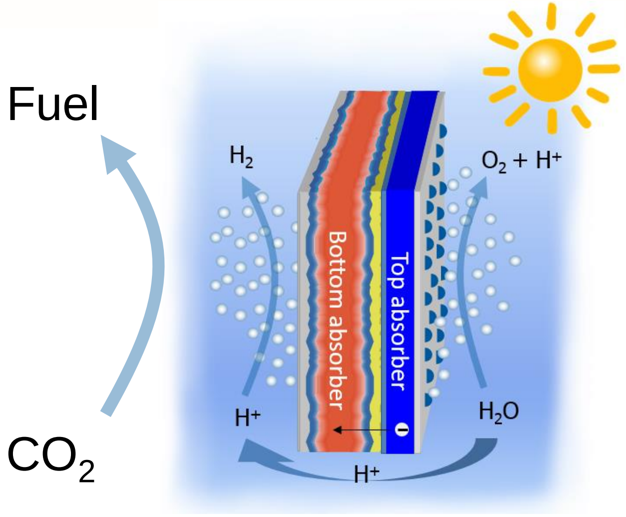
Current water electrolyzer technologies only split either highly alkaline (20–40 wt% KOH) electrolyte obtained from purified freshwater or else purified freshwater alone.

- 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.

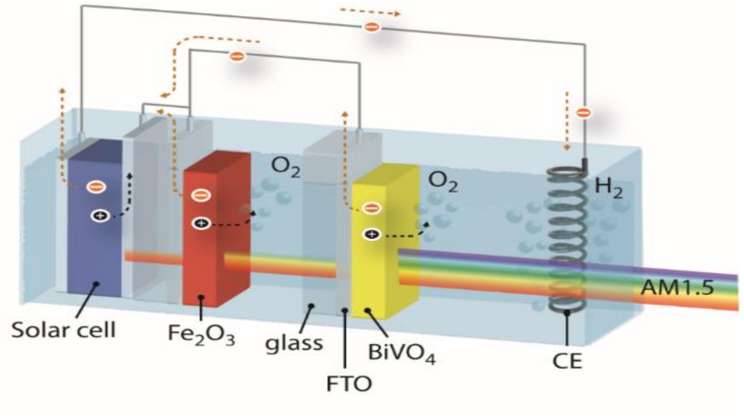
FU/TU Berlin

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

Development – Solar Fuels



From green hydrogen various pathways can lead to synthetic gas, alcohol or ammonia, being starting products for higher hydrocarbons, plastics, fertilizers via catalytic reactions



		$2H^+$	+	$2e^-$	$\rightarrow$	H_2	
CO_2	+	$2H^+$	+	$2e^-$	$\rightarrow$	$CO + H_2O$	
CO_2	+	$4H^+$	+	$4e^-$	$\rightarrow$	$HCHO + H_2O$	(formic acid)
CO_2	+	$6H^+$	+	$6e^-$	$\rightarrow$	$CH_3OH + H_2O$	(methanol)
CO_2	+	$8H^+$	+	$8e^-$	$\rightarrow$	$CH_4 + 2H_2O$	(methane)
$2CO_2$	+	$12H^+$	+	$12e^-$	$\rightarrow$	$C_2H_4 + 4H_2O$	(ethylene)
N_2	+	$6H^+$	+	$6e^-$	$\rightarrow$	$2NH_3$	(ammonia)

7.7% solar-to-H_2 efficiency *en route* to the goal for practical solar hydrogen production, *Nat. Commun.* 7, 13380 (2016)

- Key challenge 1: Understanding surface chemistry during operation
- Key challenge 2: Optimizing catalysts for the different reactions
- New developments in synchrotron methods allow study of solid-liquid interfaces with XPS

J. Electron Spectrosc. Relat. Phenom. 221, 106 (2017); J. Phys. Chem. B 122, 801 (2018)

CATlab

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

HZB Helmholtz Zentrum Berlin

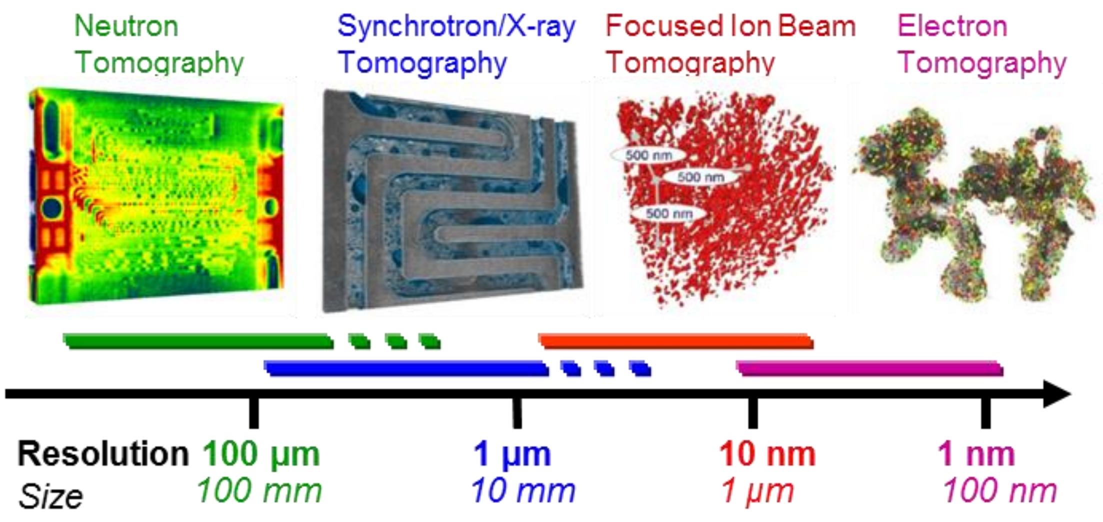
Batteries - the major technological challenge for green energy storage

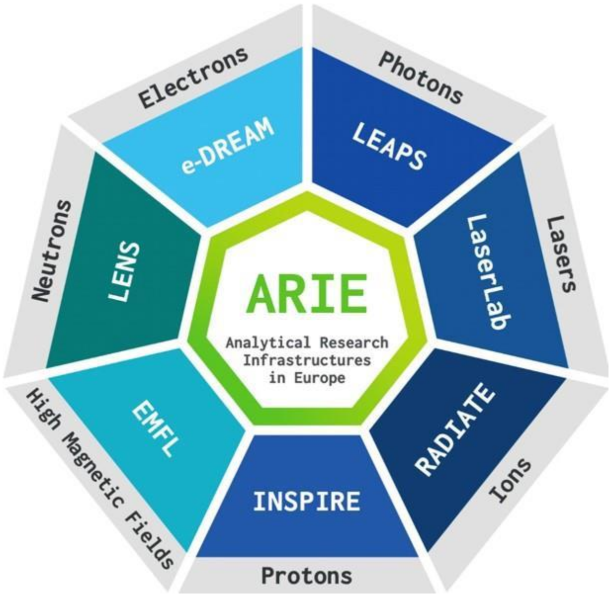
The perfect battery

- has a high capacity,
- short charging times,
- long-term stability (many charge-discharge cycles),
- is light weight and
- consists of abundantly available cheap materials.

All these properties can already be fulfilled, yet not in one but "rather 4 different batteries".
Molecular understanding, is required for rational design of new batteries

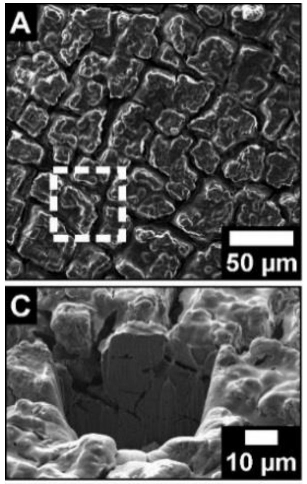
All European synchrotrons have accepted the battery challenge (see: LEAPS paper:European Battery 2030+) More than that , ARIE (Analytical Research Infrastructures In Europe) addresses 40,000 researchers in academia and industry and offers complementary methods

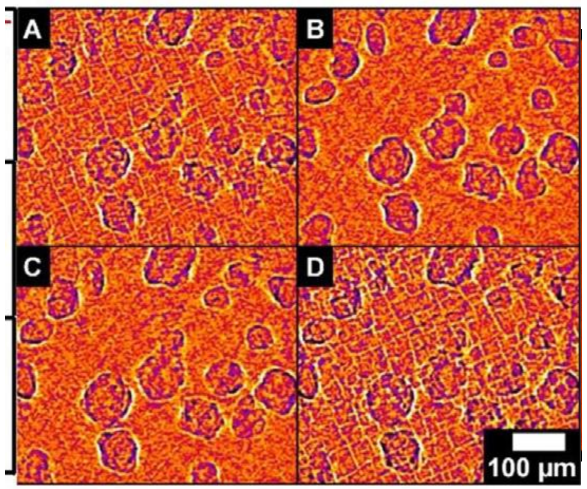




Kia, Hyundai skip hybrid car developments in favour of fully electric cars, VW develops two way batteries for grid solutions

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

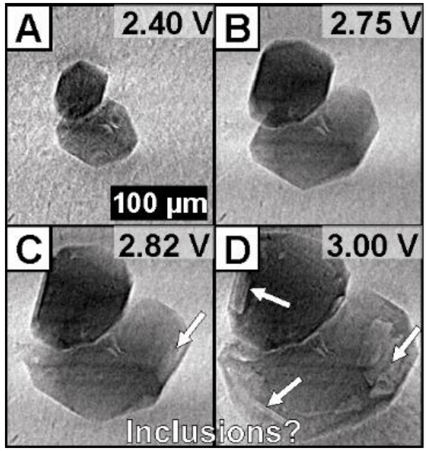




Operando analysis of a lithium/silicon half cell. Voltage-dependent morphological changes on the two electrodes.

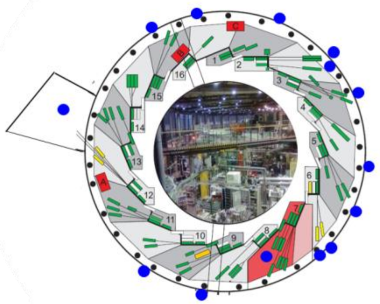
So-called lithium corrosion pits form on the metallic lithium anode and a checkerboard pattern on the silicon cathode.

- Checker board pattern on silicon electrode
- Pit corrosion at Li metal electrode
- Mechanical cracking after delithiation of highly lithiated phase



Investigation of electrochemically induced alpha-sulphur crystal growth in lithium/sulphur batteries.

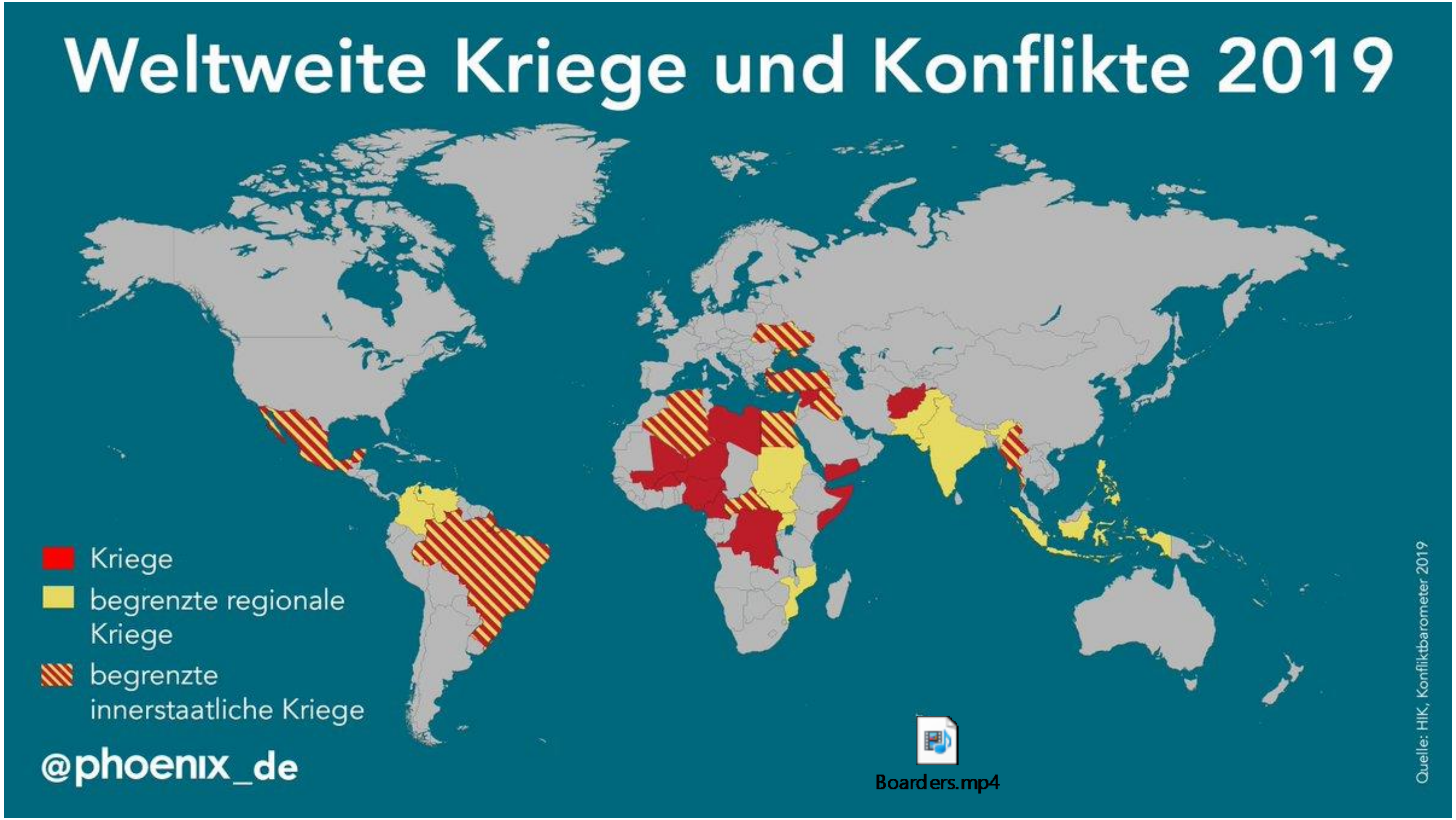
During rapid growth, liquid inclusions can apparently form that trap active material, which is thus no longer available for energy storage. This represents a new capacity loss mechanism



Energy Storage Materials 32 (2020) 377–385 ; . Phys. Chem. Lett. 11 (2020) 5674–5679

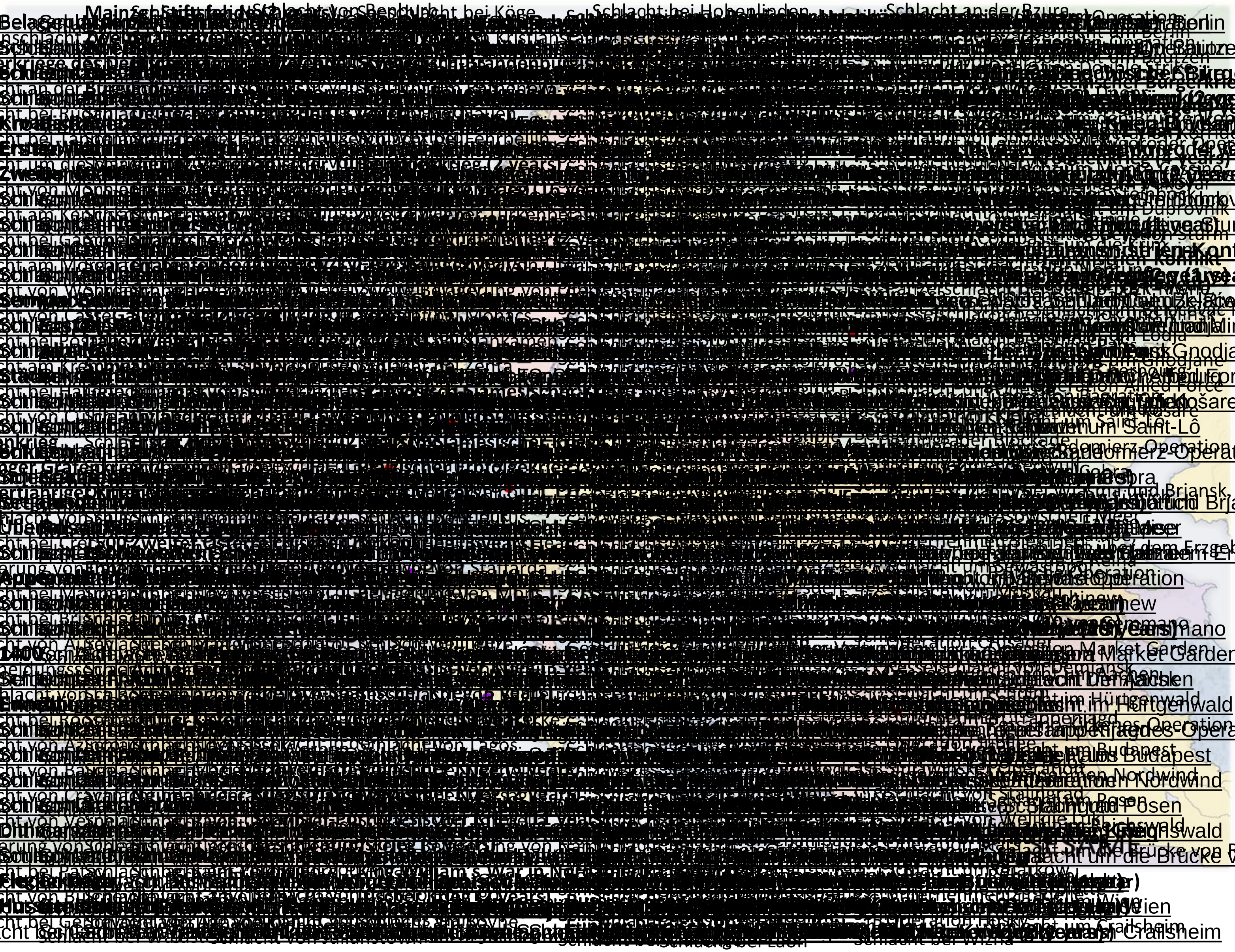
HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

HZB Helmholtz Zentrum Berlin

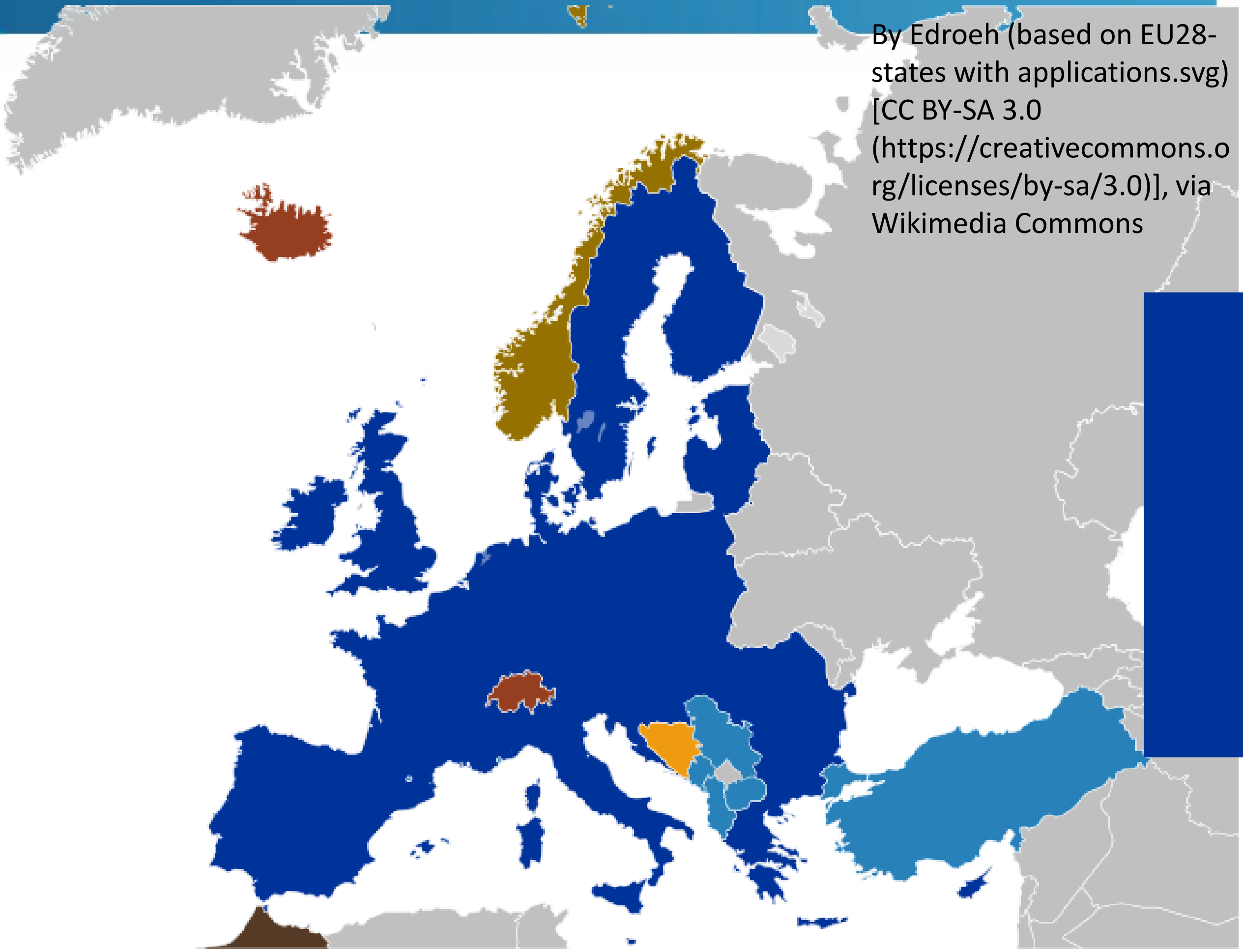


Boarders.mp4

WARS AND BATTLES IN EUROPE SINCE THE MIDDLE AGE



GLOBAL CHALLENGES



By Edroeh (based on EU28-states with applications.svg) [CC BY-SA 3.0 (https://creativecommons.org/licenses/by-sa/3.0)], via Wikimedia Commons

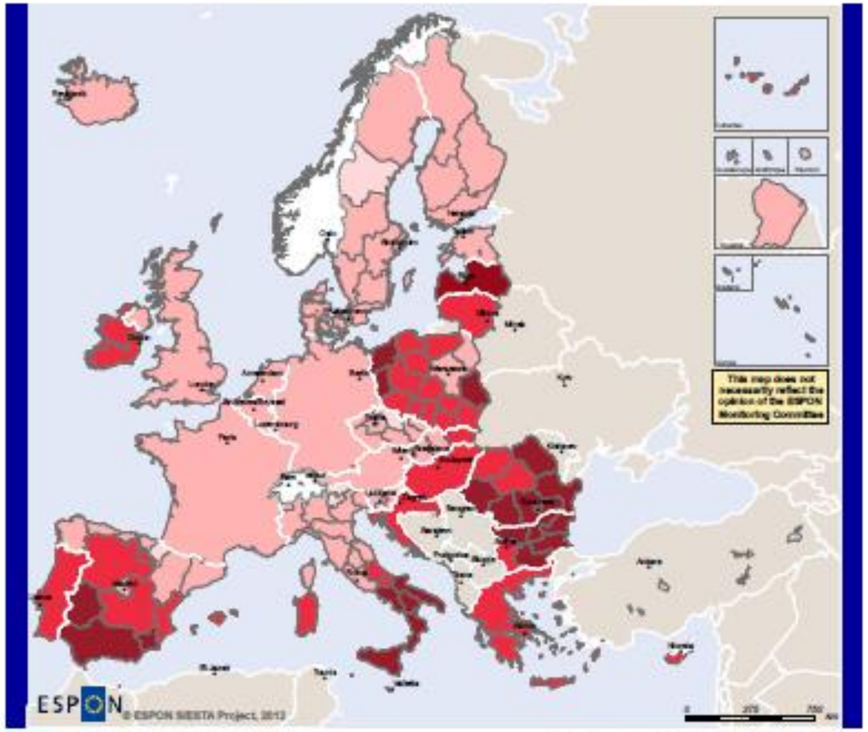
- EU
- Candidate countries
- Formally submitted membership application to EU
- Accession rejected (referendum 1972 and 1994
- Application frozen or withdrawn
- Application rejected

EUROPEAN CHALLENGES

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

HZB Helmholtz Zentrum Berlin

Map 4.9 Distance to the Europe 2020 target of population at-risk-of-poverty or social exclusion, 2010

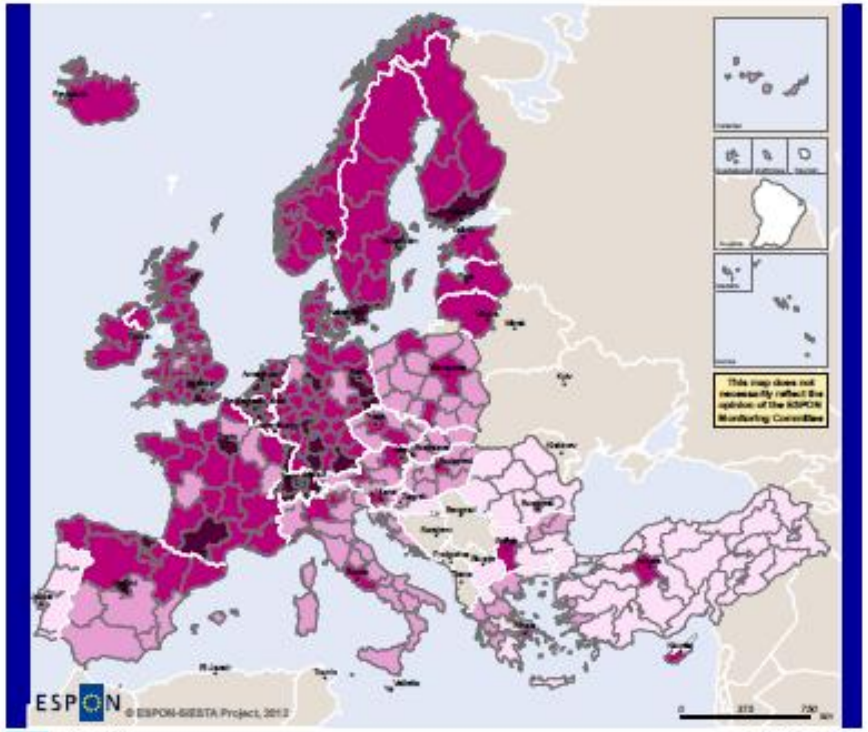


Distance in percentage of population at risk of poverty or social exclusion in relation to EU 2020 Target (%).

Above EU 2020 Target (%)

- < 2%
- 2% - 4%
- 4% - 6%
- > 6%
- No data

Map 2.4 Human resources in science and technology (HRST) as share of active population, 2010



HRST in relation to active population (%), 2010.

- < 25%
- 25% - 35%
- 35% - 45%
- > 45%
- No data

http://atlas.espon.eu/

EUROPEAN CHALLENGES

Inclusion always starts with information…

Confidence always starts with experience…

- Tailor made twinning teams of new comers and experienced user groups
- Experience in possibilites and experiments
- Discussion and support
- Contact to facilities and possible collaborators

Exchange programs, schools, workshops, e-learning, web-pages, and social media accompany international activities.

Cooperation always starts with a common idea and a project between partners…

Examples of bridges between peoples built by CERN

- 1st intergovernmental organisation that Germany joined after WW II (on probation!)
- 1st post WW II meetings between German and Israeli physicists at CERN
- Collaboration between CERN and Russia at the height of the Cold War kept door open, establishes trust and was model for USA-Russian collaboration
- In the 1970s, when China was "closed"scientific contacts were pioneered at DESY and CERN – Nobel Laureat Sam Ting (MIT) got backing from Deng Xiaoping
- In 1985, when USSR-USA arms negotiations in Geneva were stalled, a dinner for Russian and American scientific advisors was arranged, which facilitates a subsequent breakthrough
- CERN had an open door policy for East European countries during the Cold War – this allowed them to quickly join CERN following the fall of the Berlin wall

1954 European Reconstruction
1st Session of CERN Council

1980 The East Meets the West
Visit of delegation from Beijing

Today The LHC brings together > 8000 scientists and some 100 nationalities

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

CERN and SESAME and more….

HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES

HZB Helmholtz Zentrum Berlin

(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

…but what can be the roll of synchrotrons in the world?

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. Cheaper ones or expensive ones. A lot of R&D, and there were a lot of discussions. You can read about it. About how one should invest to get a better candle. 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. (…)




Thank you for your kind attention

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

Thinkable pathways for bridging energy materials simulations to synchrotron experiments

[AMD]

Süleyman Er
Research Group Lead
Autonomous Energy Materials Discovery [AMD]

DIFFER

NWO

14-Apr-2021

Automating energy materials modelling

High-throughput virtual screening:

Speed. Massively parallel

Scale. Thousands of candidates

Low-cost. Capital and operational

Computer simulations:

Predict properties

Suggest new materials

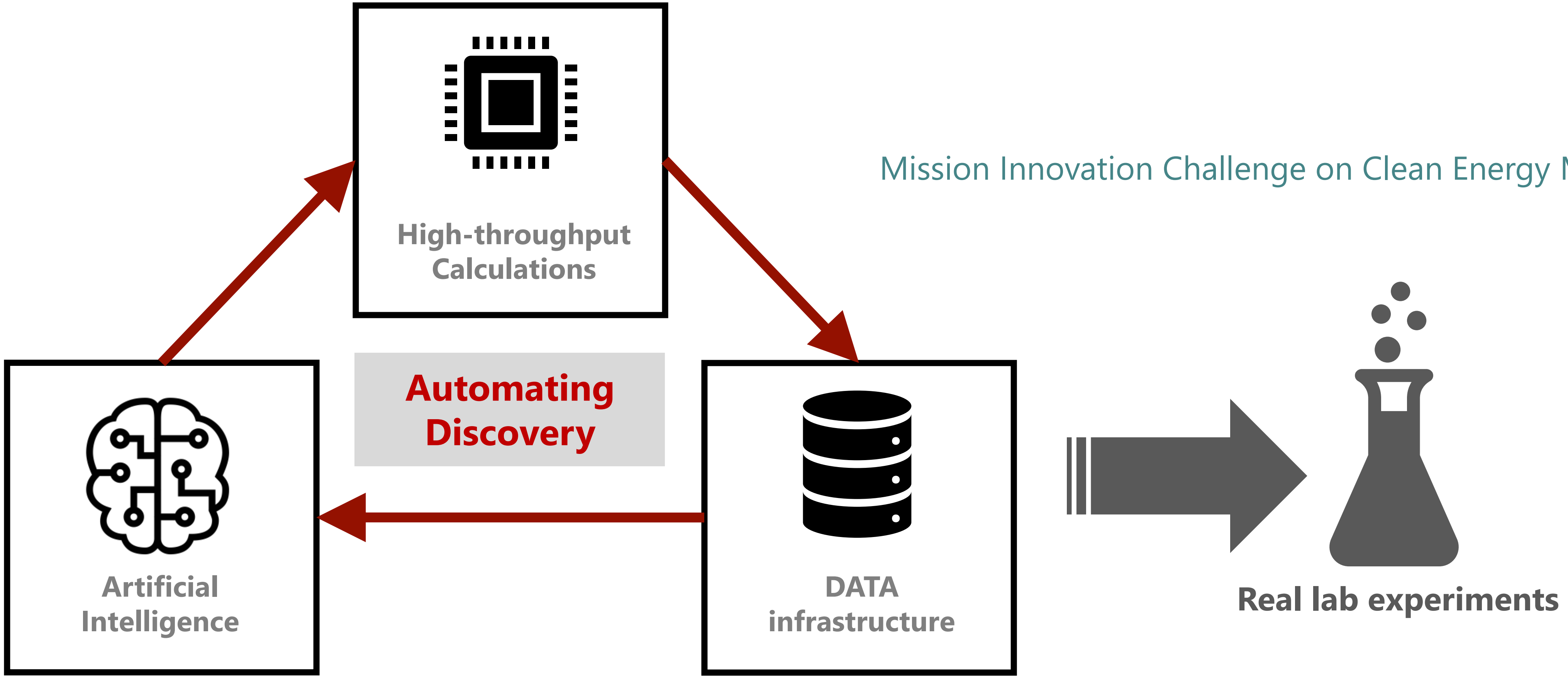
Easy to reproduce

Quantum chemistry:

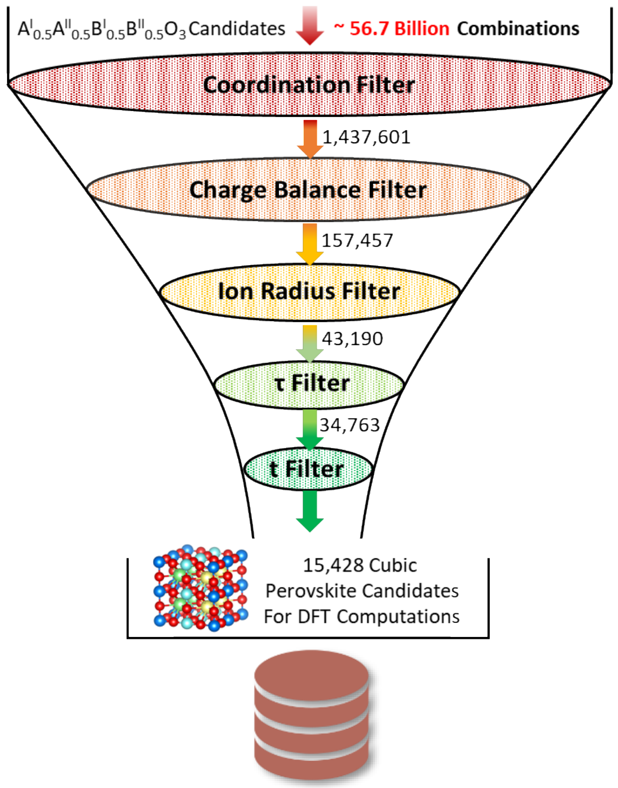
Fundamental interactions in materials are governed by their electronic structures

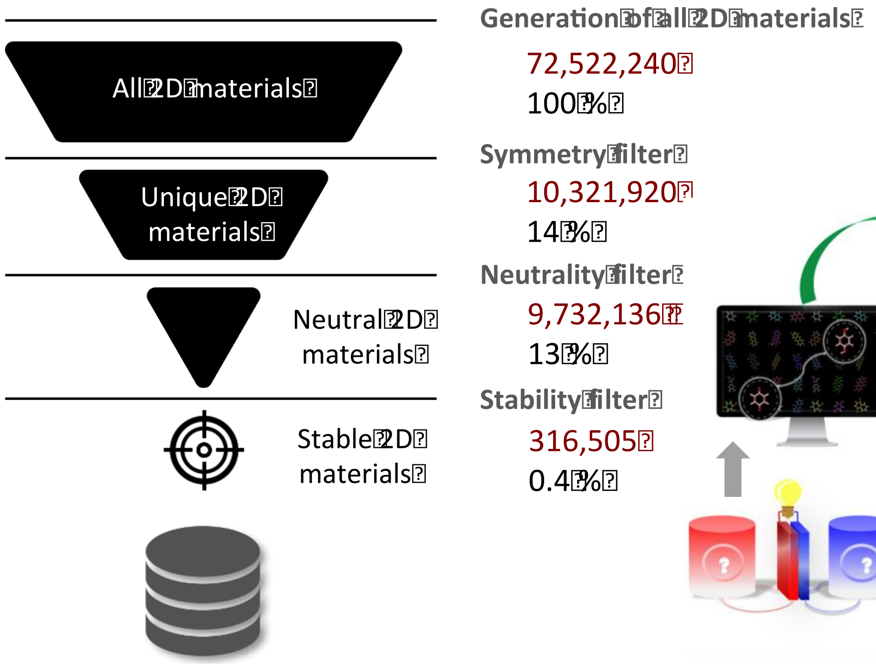
Computation and data-driven energy materials discovery at [AMD] DIFFER

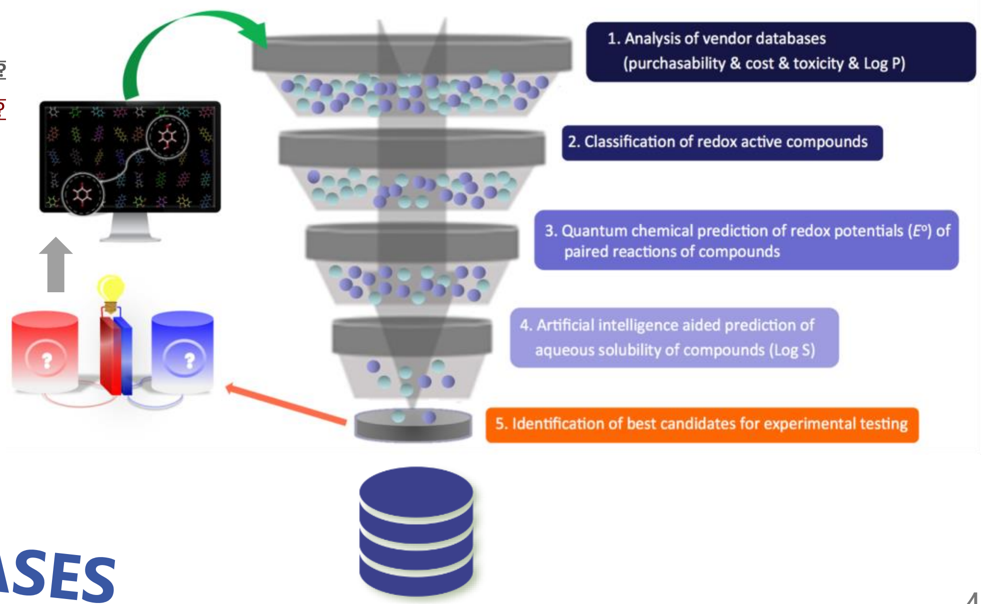
Mission Innovation Challenge on Clean Energy Materials



Automating the discovery of 3, 2 and 0 dimensional energy materials



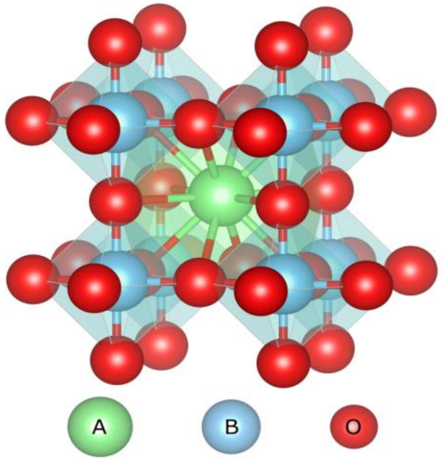




ENERGY MATERIALS DATABASES

High-throughput DFT calculations for virtual materials screening

Discovery of 3D electro-catalysts for solar fuel generation



Which perovskite materials are good for:

CO_2 catalysis?

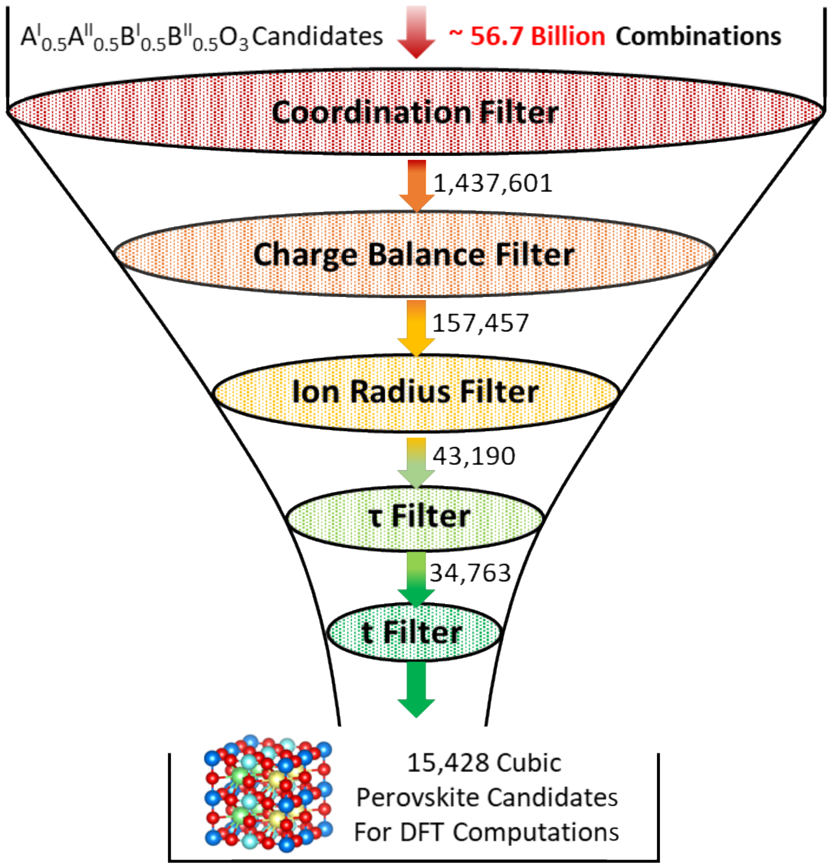
O_2 catalysis?

O transport?

H_2 production?

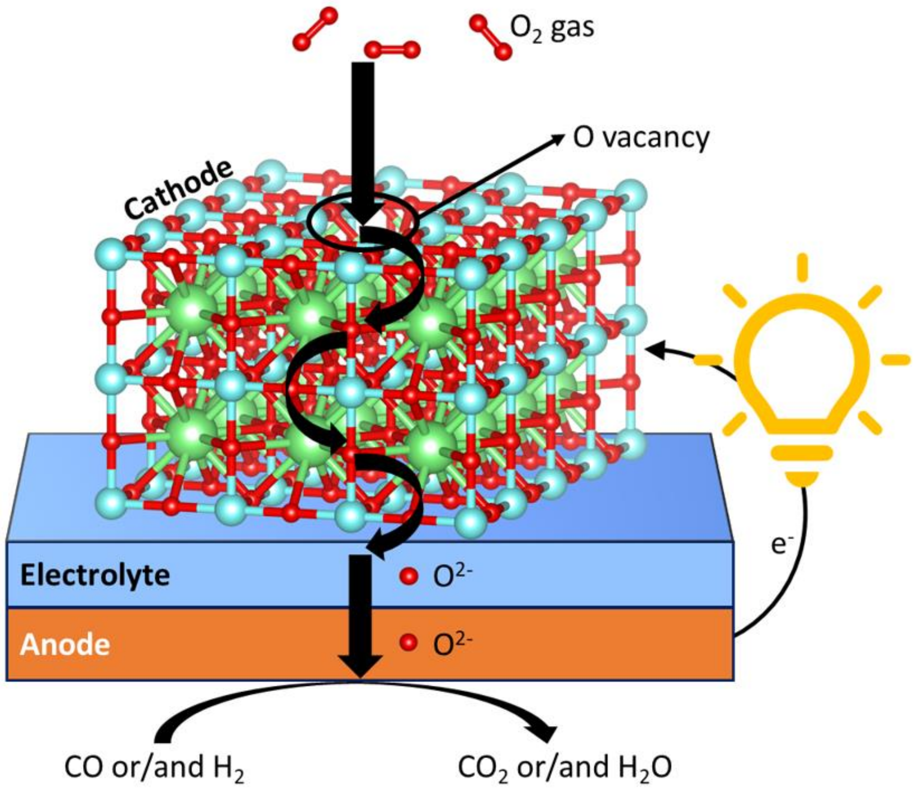
… etc. ?

Automating 3D materials discovery using HT-DFT



Perovskite cathode materials for solid oxide fuel cells (SOFC)

A schematic representation of oxygen utilization in SOFCs.

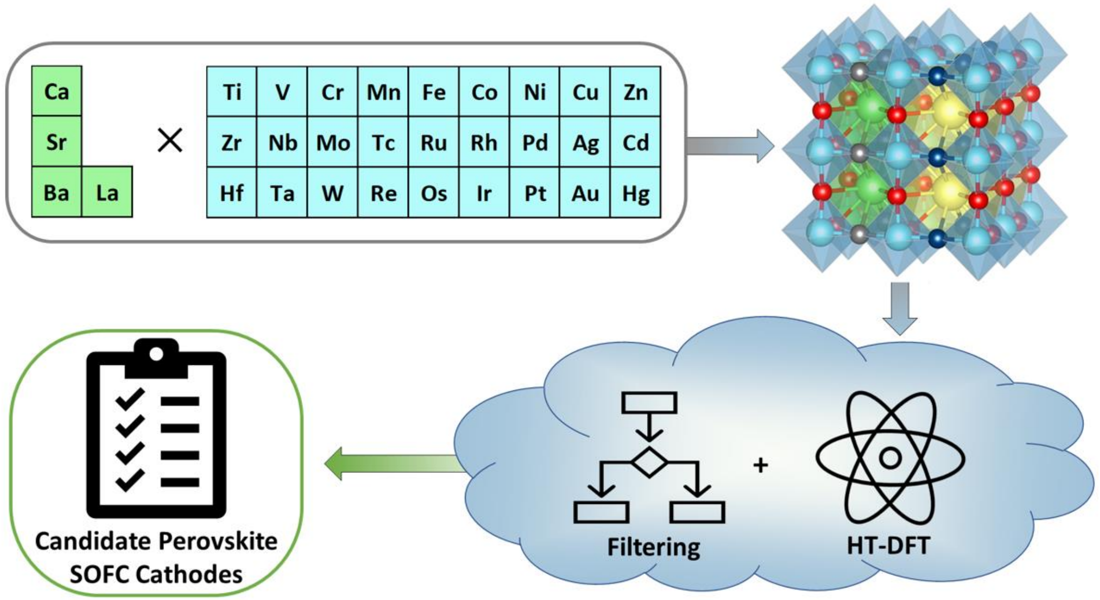


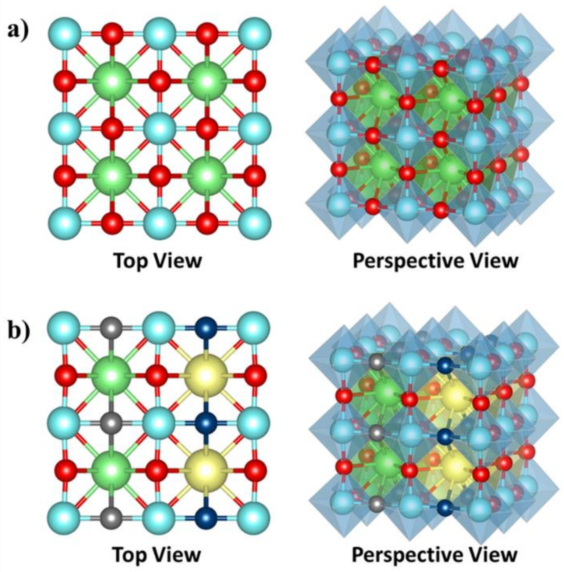
Only the perovskite structure of the cathode is depicted

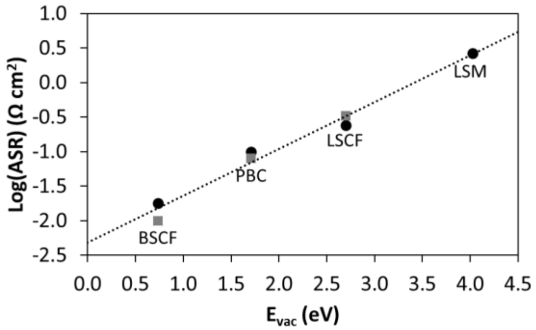
Oxygen atoms are shown with red, A-type perovskite atoms with green, and B-type perovskite atoms with blue colored spheres

In review; preprint at: https://doi.org/10.26434/chemrxiv.14213900

High-throughput computational screening of cubic perovskites for their use as SOFC cathode materials





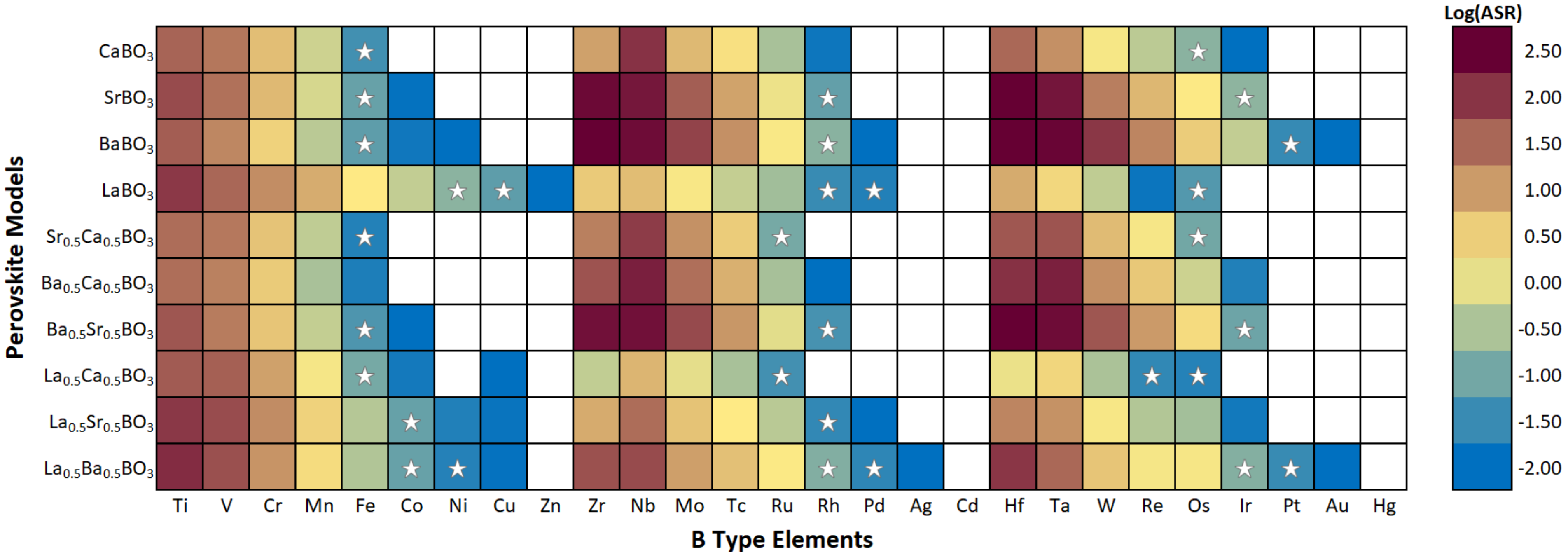


Using E_{vac} data of perovskites as descriptor, the area-specific resistance (*ASR*) is calculated

ASR is related to both oxygen reduction reaction activity and selective oxygen ion conductivity of materials

In review; preprint at: https://doi.org/10.26434/chemrxiv.14213900

A heat map of the best candidate SOFC cathode materials



The most promising compounds are indicated by using a star sign

The likely unstable perovskites are shown with blank cells

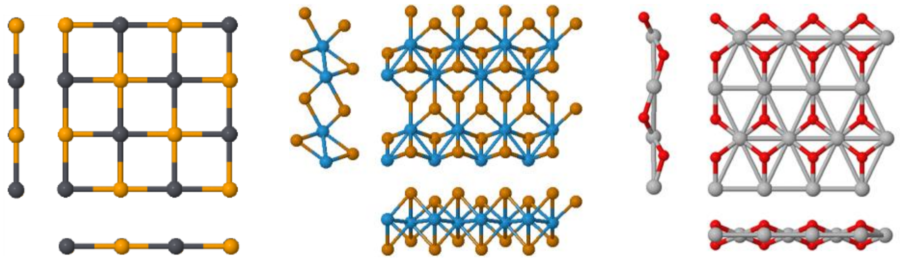
In review; preprint at: https://doi.org/10.26434/chemrxiv.14213900

AI-aided virtual design of 2D energy materials

Discovery of 2D photo- and electro-catalysts for solar fuel generation

2D materials overview

Samples of 2D materials



Attractive properties

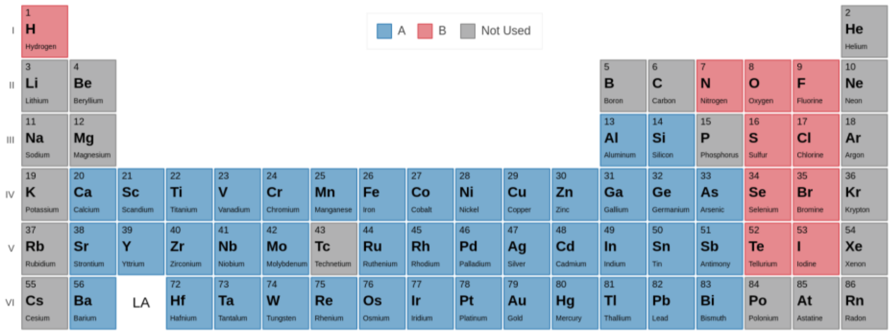
- *thin (less material use, large surface)*
- *diversity of structures*
- *tunable properties*

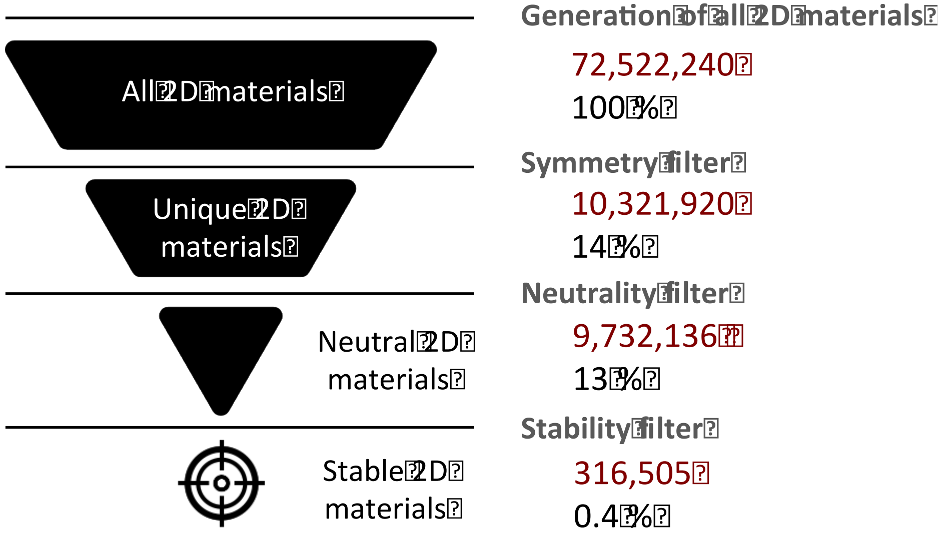
Promising high-tech applications

- *energy conversion and storage*
- *semiconductors*

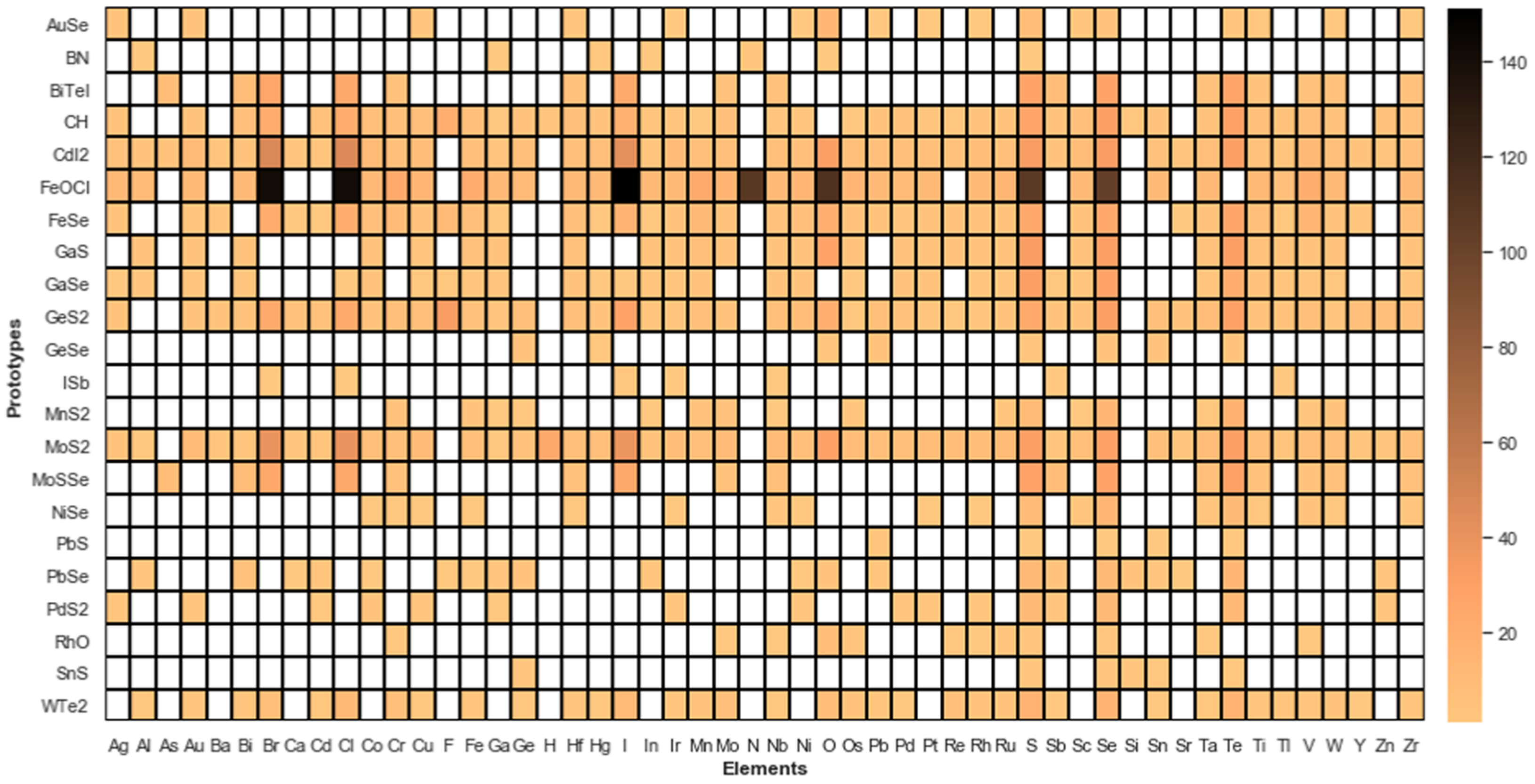
Only few thousands DFT calculated

Automating 2D materials discovery using Artificial Intelligence (AI)





The heatmap of chemical screening space for 2D materials

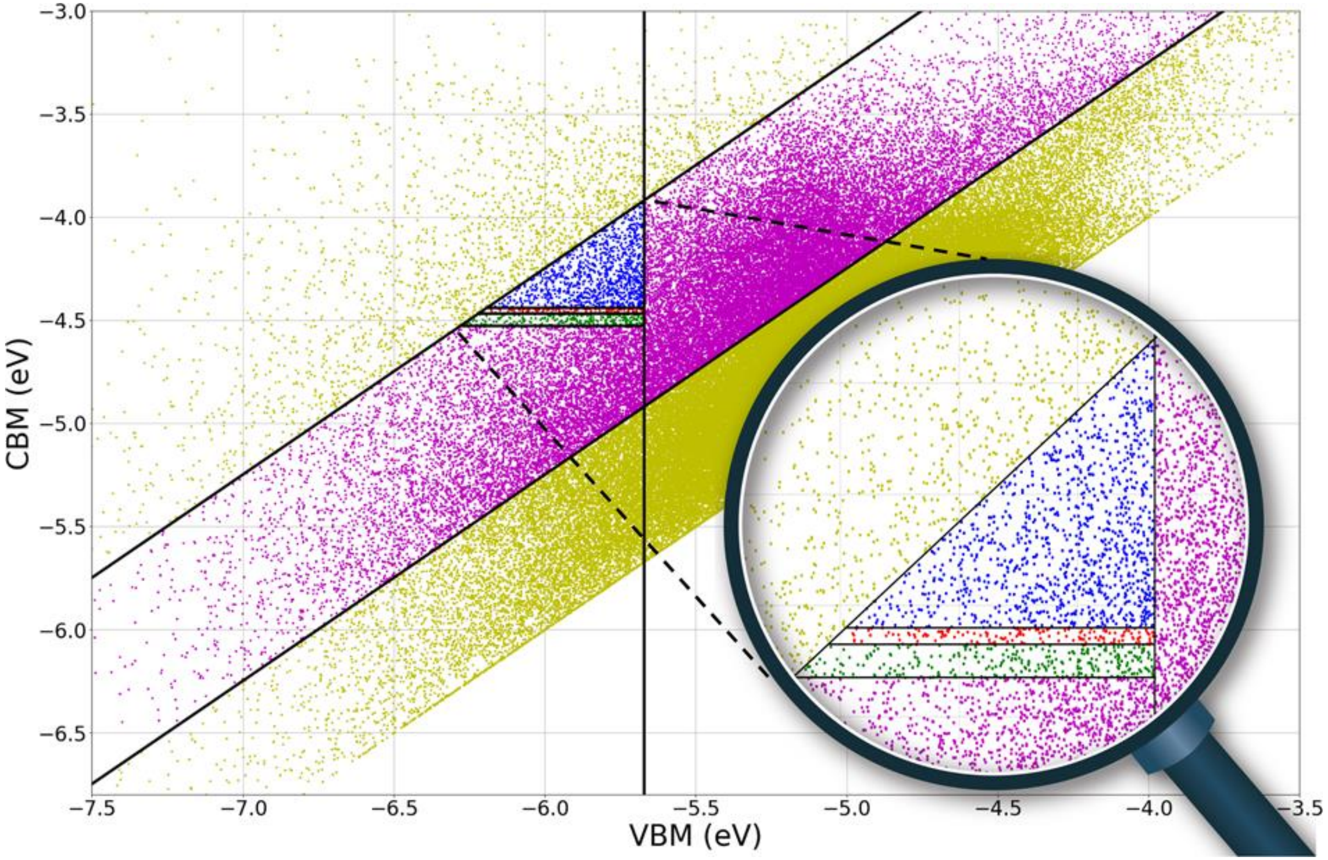


Dark colors show well represented 2D materials in the AI model training data

White color shows absent 2D materials in the AI model training data

Virtual screening of AI-predicted candidate 2D materials for different renewable energy technologies

69,288 materials for photovoltaics

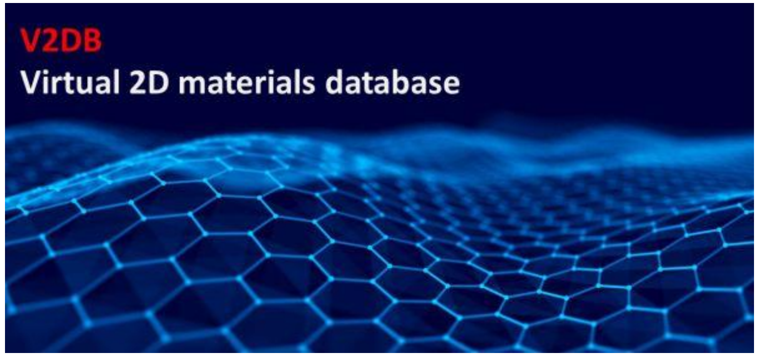


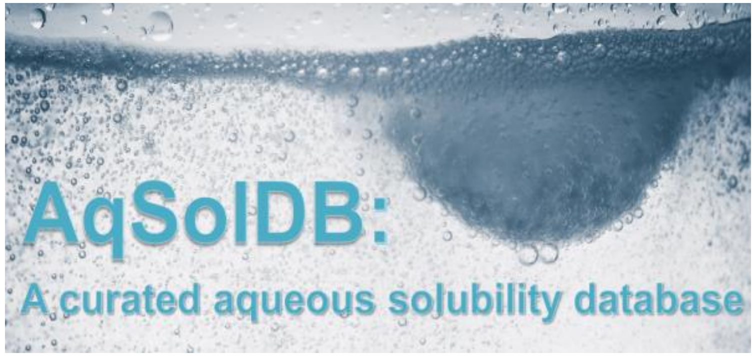
2,363 materials for H_2O conversion

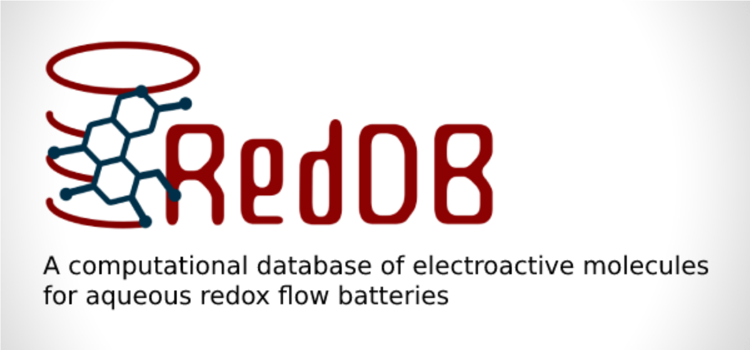
337 materials for CO_2 conversion

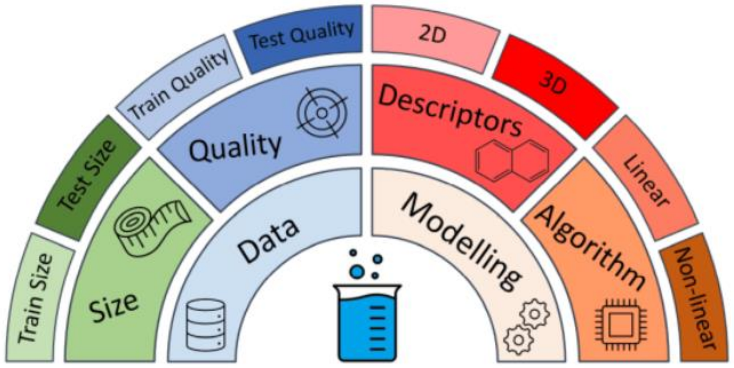
987 materials for N_2 conversion

Open Databases & Software at: www.amdlab.nl/software-data

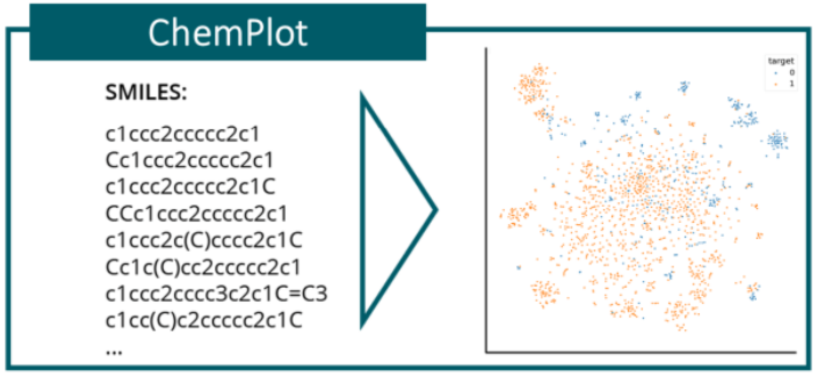






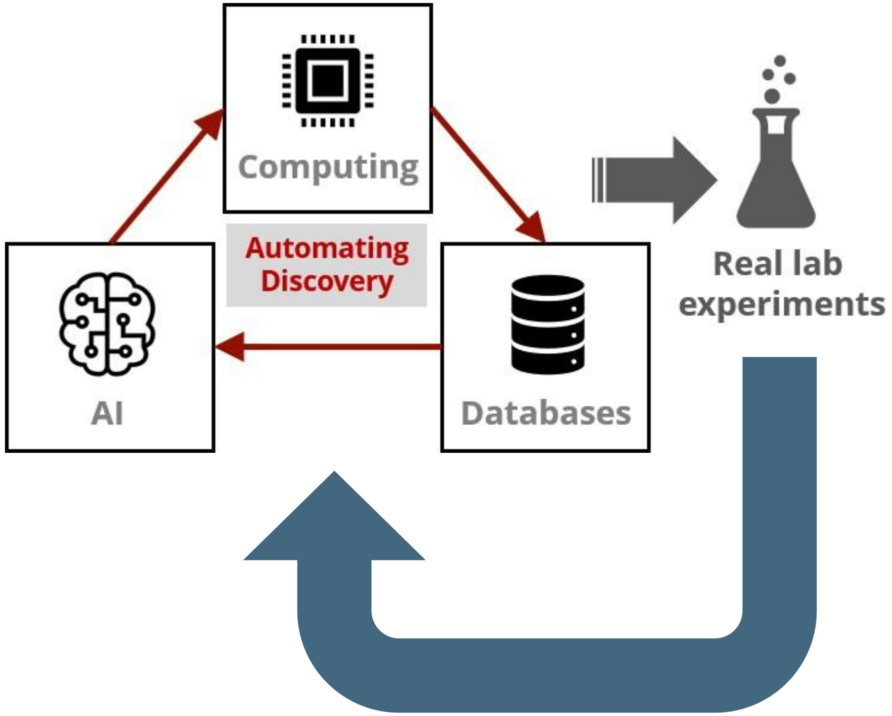


AqSolPred: aqueous solubility prediction tool



ChemPlot: python library for chemical space visualization

A future feedback loop between modelling and (synchrotron) experiments



Spectroscopic and Diffraction/Diffusion techniques related to:

(*operando*) bulk atomic structural features (batteries)

(*operando*) surface atomic structural features (catalysis)

Reactivity of molecules on surfaces (catalysis)

Electronic structure (photo/electro-catalysis, batteries)

Matter under extreme condition (fusion/space)

Contact

Süleyman Er
[AMD] Research Group Leader
+31 (0) 40 3334 936
s.er@differ.nl
www.amdlab.nl

DIFFER
Eindhoven, The Netherlands
info@differ.nl | www.differ.nl

The Way Forward -
The Clean Energy Transition Partnership (CETP)

Nikolas Reschen, Austrian Federal Ministry for Climate Action

EERA JP ES webinar

14th of April 2021

Outline

- The Clean Energy Transition Partnership – What is it?
- The CETP in a broader policy context and the European Ecosystem
- CETP Challenge 3: Enabling Climate Neutrality with Storage Technologies, Renewable Fuels and CCU/CCS
- The Way Forward

Clean Energy Transition Partnership

What is it?

- The planned **Clean Energy Transition Partnership (CETP)** is a **multilateral and strategic partnership of national and regional RDI programmes** in EU Member States and Associated Countries
- Its **Strategic Research and Innovation Agenda (SRIA, 2020)** serves as **guidance document** for future collaboration and focus points. The development of the SRIA was **facilitated by the great work of EERA** members.
- **Eight CETP challenges** related to enabling technologies and system integration have been formulated.

CETP in a broader policy context

UN Sustainable Development Goals

EU Climate Ambition

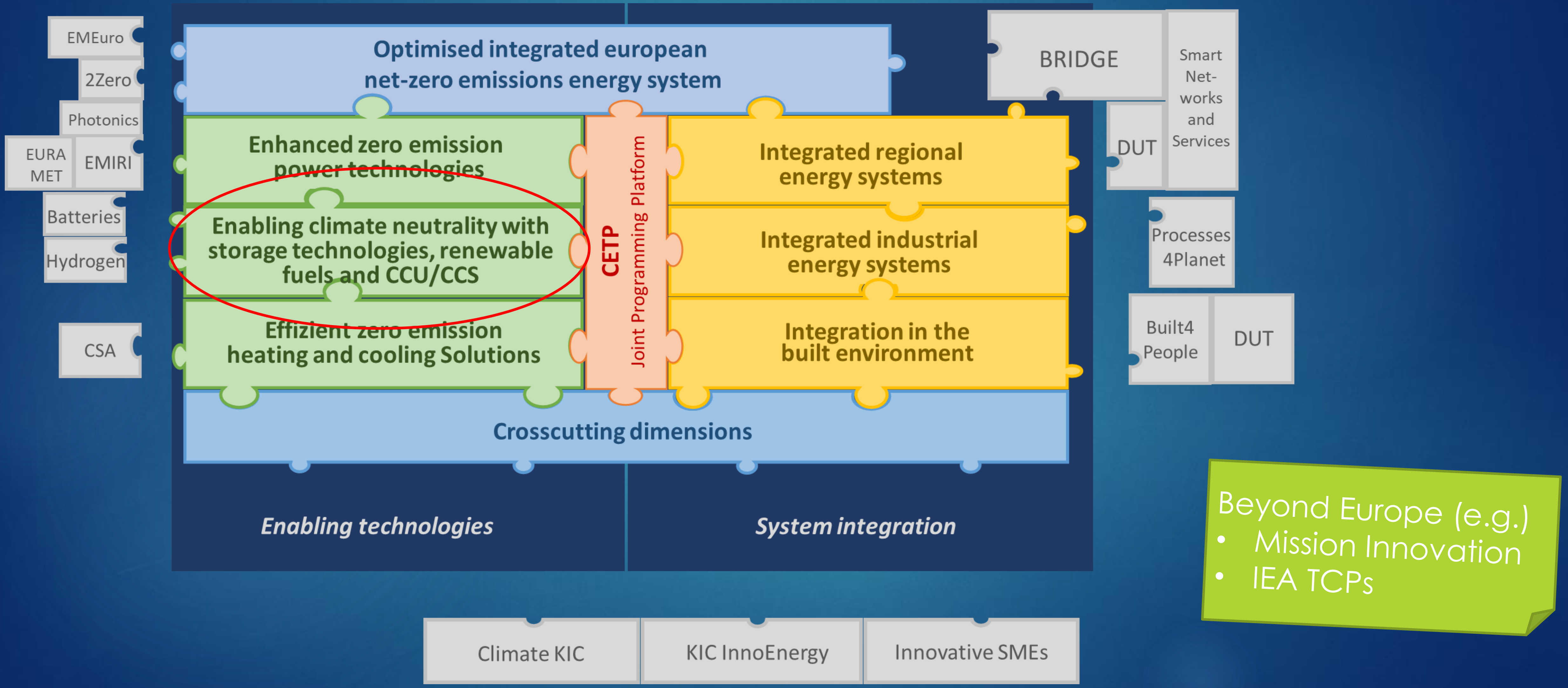
- A Clean Planet for All
- The European Green Deal
  Energy System Integration strategy and Hydrogen Strategy
  Renovation Wave strategy
  Off shore Renewable Energy strategy
  Biodiversity strategy

- National Energy and Climate Plans
- EU Competitiveness Progress Report
- Recovery and Resilience Facility, within the Next Generation EU Programme
- EU Taxonomy

RDI for the clean energy transition

- A new European Research Area (ERA)
- European Strategic Energy Technology Plan (SET Plan)
- International Collaboration: Mission Innovation and the International Energy Agency

CETP in the European Ecosystem



CETP Challenge 3 (I)

Enabling Climate Neutrality with Storage Technologies, Renewable Fuels and CCU/CCS

- The aim of the challenge is to ***develop and deploy energy storage, renewable based fuels, as well as CCU/CCS (Carbon Capture and Use/Carbon Capture and Storage) for a climate-neutral Europe***
- The challenge responds to ***regionally differing energy policies, meteorological conditions, geography and macroeconomic conditions***.
- An **input paper on Storage & Fuels Technology**, serving as a basis for Challenge 3, has identified 5 challenges (with several subchallenges) that are of particular importance:

CH4.1 Reliable and cost-effective mid- to long-term thermal storage systems
CH4.2 Development of efficient storage technologies for electric power grids based on renewables
CH4.3 Renewable Fuels
CH4.4 Development of Cross-sectoral and hybrid energy storage solutions
CH4.5 System integration and cross-cutting issues for energy storage

CETP Challenge 3 (II)

Enabling Climate Neutrality with Storage Technologies, Renewable Fuels and CCU/CCS

- **Technologies and resources** considered of particular importance in challenge 3 (among others):
  - Fuels and fuel technologies for hard-to-carbonize sectors (e.g. through CCU/CCS technologies including integrated hydrogen production)
  - Reliable and cost-effective mid- to long term thermal storage systems
  - Hydropower storage
  - Thermal energy storage
  - Efficient storage technologies for electric power
  - Green and blue hydrogen
- Because of its **cross-cutting role**, storage and fuels are expected to also play a significant role in system integration challenges, namely integrated regional systems as well as industrial systems

CETP Challenge 3 (III)

Enabling Climate Neutrality with Storage Technologies, Renewable Fuels and CCU/CCS

What is the **added-value** for **international collaboration**?

- Challenge is highly suited for transnational programming in Europe and beyond, through excellent alignment with national and regional RDI programming
- Projects are expected to **not only address technical issues**, but also consider **social issues** in order to achieve the optimal input for the clean energy transition
- **Expected responders** to calls set up under this challenge:
  - European technology companies and research organisations
  - Builders and operators of European energy infrastructures
  - Original equipment and component manufactures as well as
  - Materials suppliers

Clean Energy Transition Partnership

The way forward

- Clean Energy Transition Partnership has entered a **design phase** in which central **elements for organisation and operation** are developed
- The CETP is expected to become operational in **early 2022.**
- The **launch of the first call** is expected for **late 2022.**

Thank you for your attention!

Webinar on Materials for Hybrid Energy Storage

Round Table & Questions

Magdalena Graczyk-Zajac

EnBW (DE)

Antje Vollmer

HZB(DE)

Süleyman Er

DIFFER (NL)

Nikolas Reschen

Austrian Federal Ministry (AT)

Holger Ihssen

HGF (DE)

Stefano Passerini

KIT-HIU (DE)

Olga Suminska-Ebersoldt

KIT-HIU (DE)

KIT Karlsruher Institut für Technologie

JP ES Coordinator
HIU Director
Prof. S. Passerini
stefano.passerini@kit.edu

KIT Karlsruher Institut für Technologie

JP ES Manager
MTET Programme
Dr. M. E. Gil Bardají
elisa.gil@kit.edu

KIT Karlsruher Institut für Technologie

JP ES Manager
HIU
Dr. O. Suminska-Ebersoldt
olga.suminska-ebersoldt@kit.edu

KIT Karlsruher Institut für Technologie

Helmholtz Delegate
Dr. Holger Ihssen
Holger.ihssen@helmholtz.de

More information JP ES activities at www.eera-energystorage.eu

Follow us at LinkedIn www.linkedin.com

StoRIES

Storage
Research Infrastructure
Eco-System