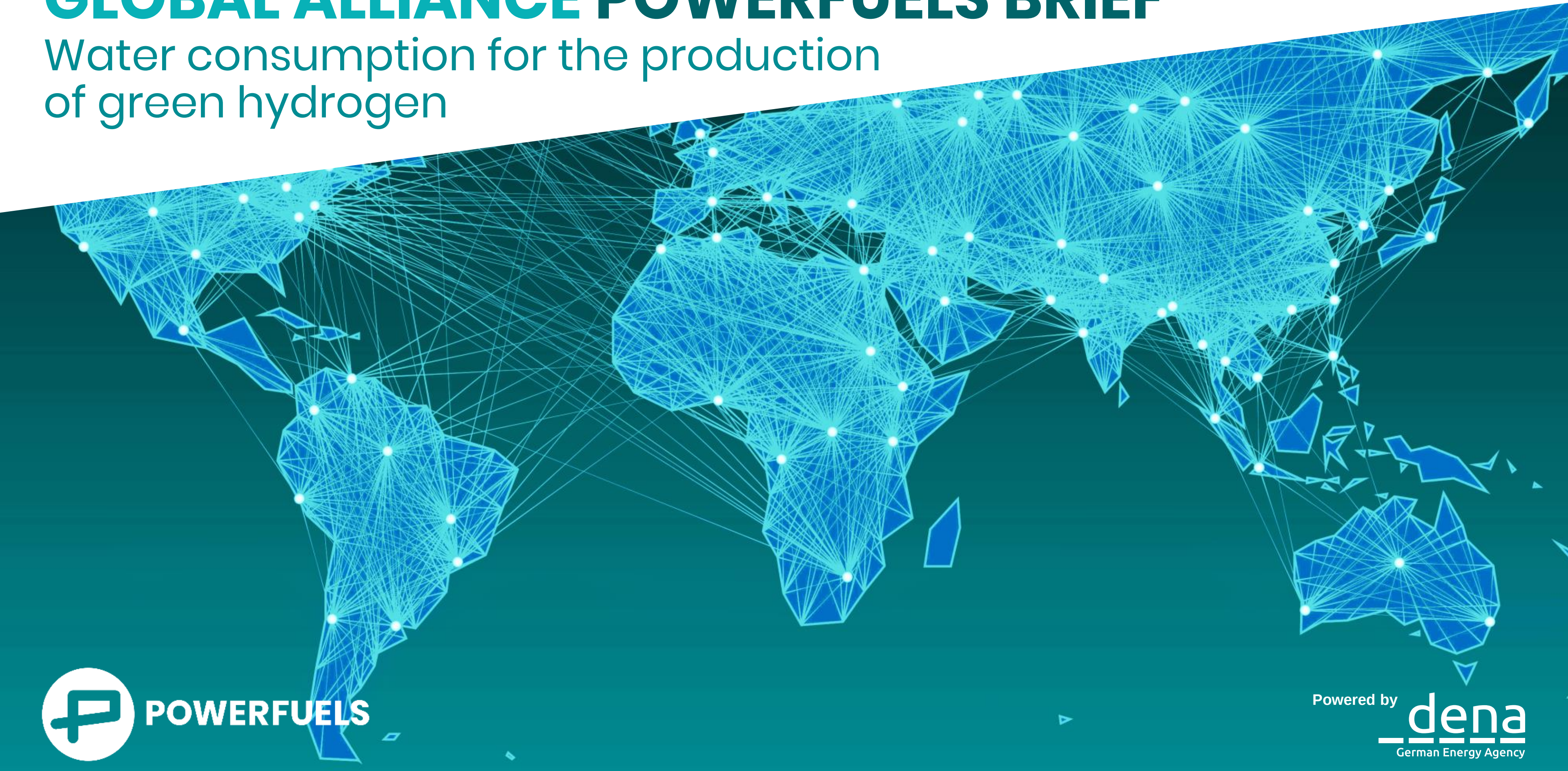
GLOBAL ALLIANCE POWERFUELS BRIEF

Water consumption for the production of green hydrogen



POWERFUELS

Powered by dena German Energy Agency

AGENDA

1. **Introduction to the Global Alliance Powerfuels**

2. **Presentation of Alliance's analysis and policy recommendations**

3. **Presentations of guest speakers**
   Rivash Panday, Specialist: Sustainable Water, Sasol
   Luciana Mendes, Business Development Clean Tech, Alfa Laval

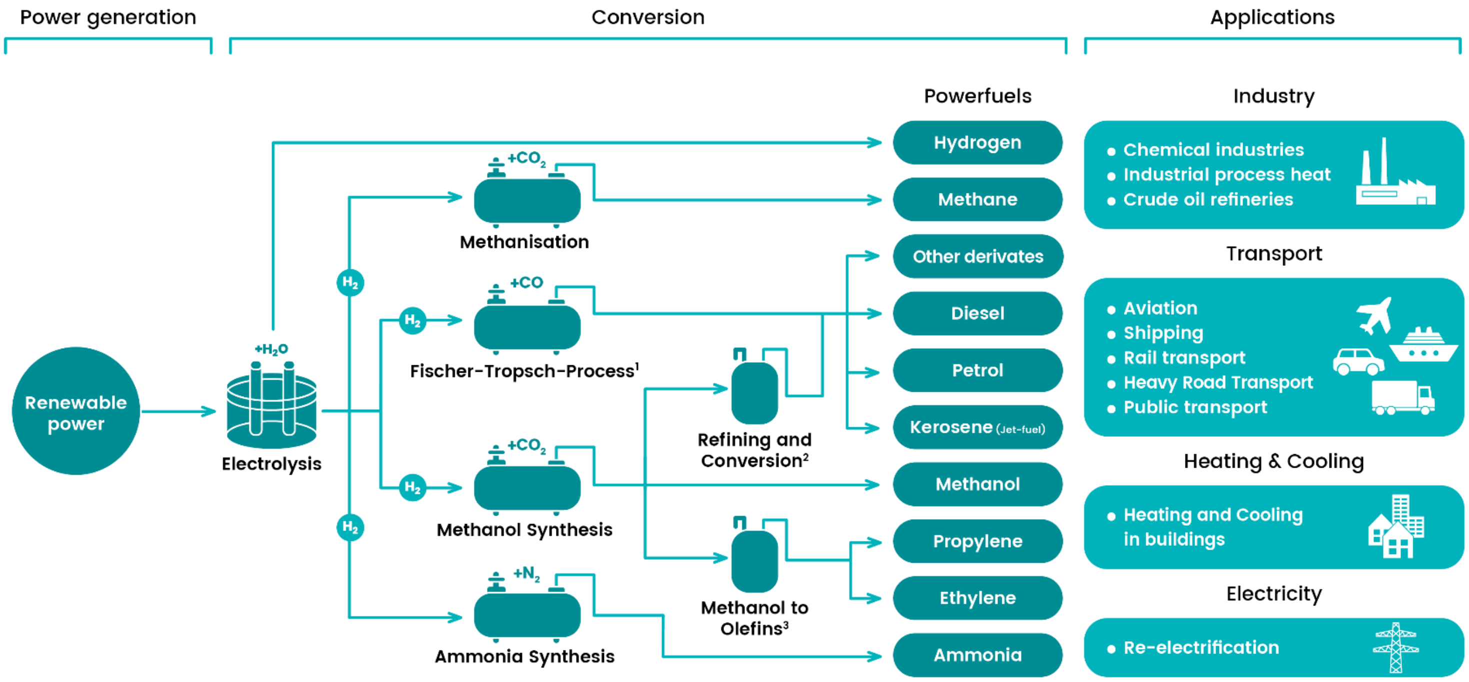
4. **Q & A and Discussion**
   Rivash Panday, Specialist: Sustainable Water, Sasol
   Luciana Mendes, Business Development Clean Tech, Alfa Laval
   Jörg Baur, Senior Energy Expert, GIZ

Kilian Crone
Team Lead,
Global Alliance Powerfuels

Friederike Altgelt
Expert,
Global Alliance Powerfuels

Matteo Micheli
Expert,
Global Alliance Powerfuels

What are powerfuels?



1 Includes: Fischer-Tropsch synthesis, hydrocracking, isomerization and distillation.

2 Includes: DME/OME synthesis, olefin synthesis, oligomerisation and hydrotrating.

3 Methanol-to-olefins process.

We strive to develop a global market for powerfuels with a unique combination of activities as…

Network

- Raising awareness for the necessity of powerfuels
- Sharing knowledge as network and information hub
- Facilitating dialogue and exchange among partners and members united by a common mission

Think Tank

- Providing strategic guidance for decision makers
- Supporting the strategic development of the EU regulatory framework
- Developing market and sustainability guidelines

Matchmaker

- Sparking new exchange between stakeholders
- Keeping an overview of market development
- Identifying business opportunities
- Initiating projects for the production of powerfuels

Our global network

Our members

sasol
Deutsche Post DHL Group
ENERTRAG Eine Energie voraus
ExxonMobil
iwo Institut für Wärme und Oeltechnik
Lufthansa
MEW Mittelständische Energiewirtschaft Deutschland e.V.
MWV MINERALÖLWIRTSCHAFTSVERBAND e.V.
Mitsubishi International GmbH
PAUL WURTH SMS group
SCHAEFFLER
sunfire

Our partners

CEF.NRW Cluster EnergieForschung
CO₂ VALUE EUROPE
DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.
ludwig bölkow stiftung
ludwig bölkow systemtechnik
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LUT University
CSIR
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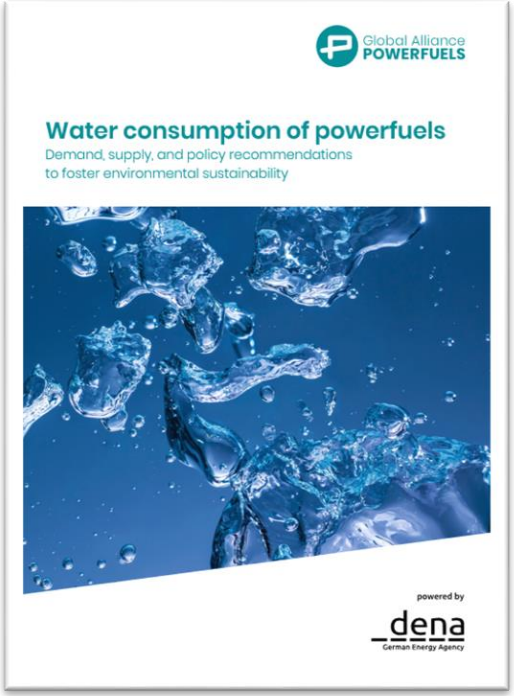
energy saxony
Empa Materials Science and Technology
SKOLKOVO Moscow School of Management
Sunrise
IRESEN Institut de Recherche en Energie Solaire et en Energies Nouvelles
FCH FUEL CELLS AND HYDROGEN JOINT UNDERTAKING
DTU
HYDROGEN VALLEY®
ENFRWC الشبكة المصرية للطاقات المتجددة والمياه Egyptian Network For Renewables and Water Cycle
EnergieAgentur.NRW

Water consumption of powerfuels – an overlooked aspect of ensuring sustainability of powerfuels?

Environmental sustainability of powerfuels

- **Electricity** sources
- **Carbon** sources
- **Water** consumption
- …



Fostering sustainable water consumption essential to ensure that ramp-up of powerfuels does not raise water stress?

WORLD ECONOMIC FORUM

Disappearing water in a warming climate

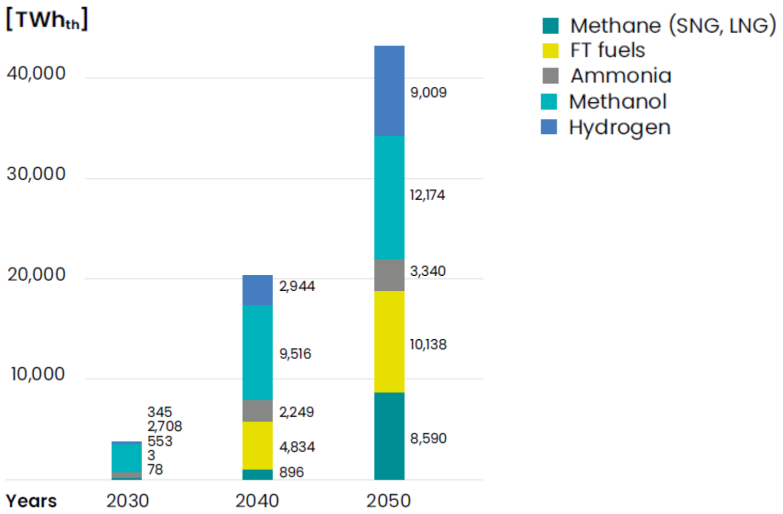
The New York Times

A Quarter of Humanity Faces Looming Water Crises

Water shortages could affect 5bn people by 2050, UN report warns

Conflict and civilisational threats likely unless action is taken to reduce the stress on rivers, lakes, aquifers, wetlands and reservoirs

Potential global demand for renewable electricity-based energy carriers and feedstocks, 2030-2050



Sources: LUT University & Global Alliance Powerfuels, 2020, Powerfuels in a Renewable Energy World; The New York Times, 2019, The Guardian, 2018; World Economic Forum, 2021

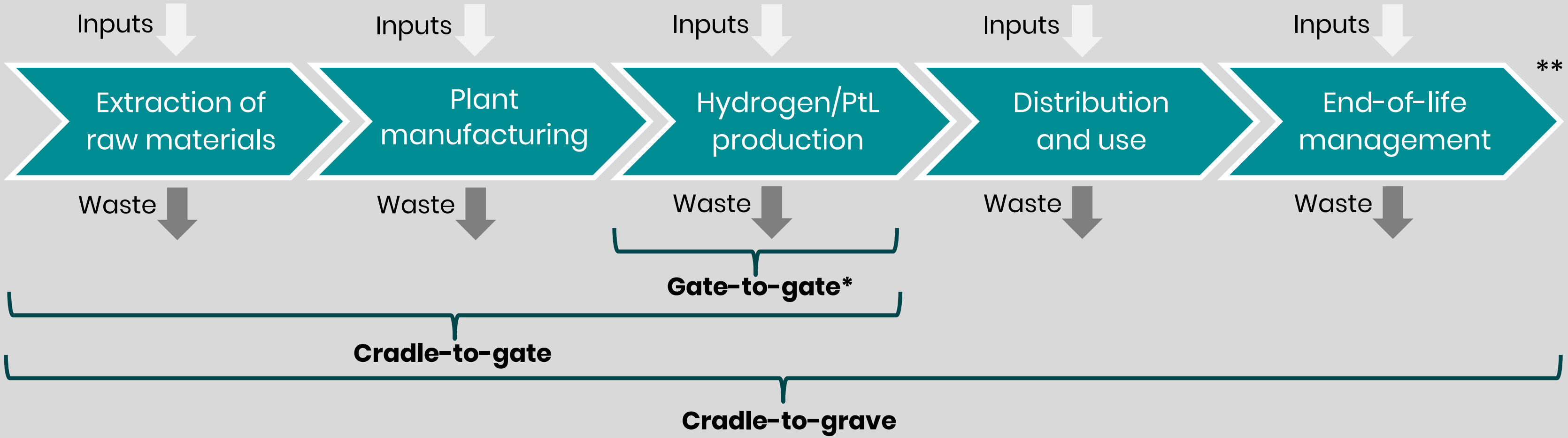
Key definitions

Water use/withdrawal
= freshwater intake from surface or ground water

≠

Water consumption
= freshwater losses on a watershed level

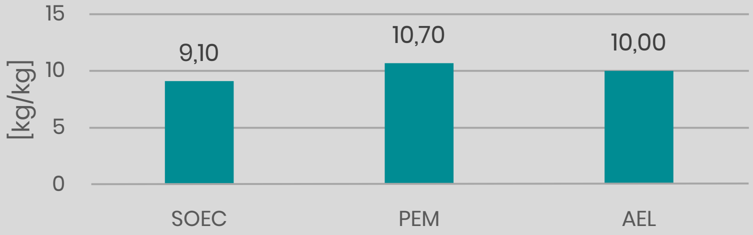
Water consumption = Water use – Water discharge



*applicable to single value-added processes, e.g. electrolysis alone
**Non-exhaustive, schematic representation of LCA system boundaries

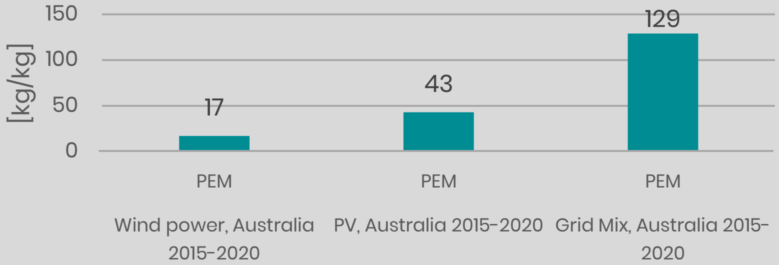
Electrolysis only vs. cradle-to-grave: hydrogen

- **Gate-to-gate water consumption** is a practical measure to quantify the water requirements of electrolysis operation → often used in public discourse ("10 kg per kg of hydrogen" narrative)
- **Smaller than total consumption for plant operation**
- Does **not capture the water consumed over the entire lifecycle** of hydrogen production



Water consumption, hydrogen, Gate-to-Gate

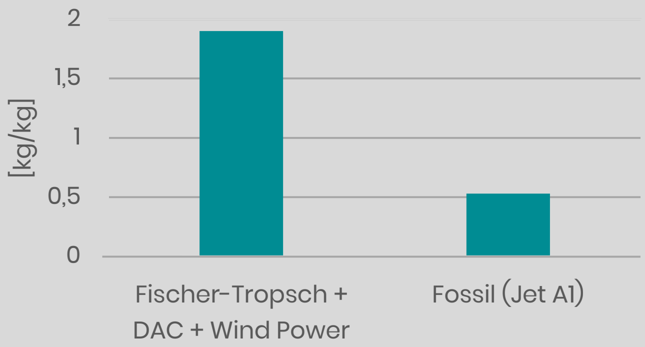
- **Cradle-to-grave** assessment shows that the amount of **water consumed over the lifecycle** of hydrogen can be **several factors higher** than the water employed for electrolysis operation alone
- Yet, it does **not necessarily provide a clear assessment of the local impact** on water consumption at the production site



Water consumption, hydrogen, Cradle-to-Grave

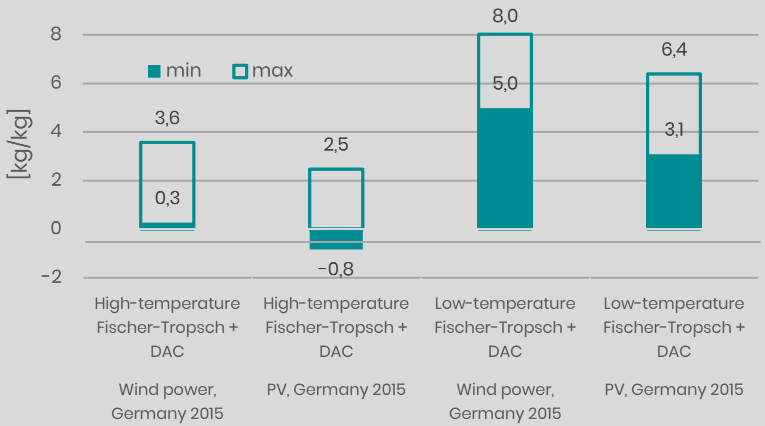
Cradle-to-grave: powerfuels beyond hydrogen

- Example of PtL-Kerosene produced in Germany
- Water consumption can either be higher than life-cycle water consumption of fossil equivalent, but also lower



Water consumption, PtL-Kerosene vs. Jet A1, Cradle-to-Grave

- High variability depending on process pathway → potential for local water co-production



Water consumption, PtL-Kerosene for different pathways, Cradle-to-Grave

Water supply in powerfuels-producing regions: Indicators of water stress and water scarcity

Indicators most frequently used to classify water scarcity can be subsumed under two categories:

Per-capita measurements of water availability

Indicate "**demographic water scarcity**"

E.g. **Falkenmark indicator**: Threshold of **1,000 m3/capita/yr** below which region is likely to face ***water scarcity***, and **1,700 m3/capita/yr** for ***water stress***

Use-to-availability / consumption-to-availability ratios

Indicate "**technical water scarcity**"

E.g. **Aqueduct 3.0 Water Stress indicator**: Threshold of ratio of **20%/40%** of total water withdrawals to available renewable water above which regions face **medium/high** ***water stress***

Water consumption = Water use – Water discharge

Water availability denotes how much of the resource is accessible for use in the respective region and period

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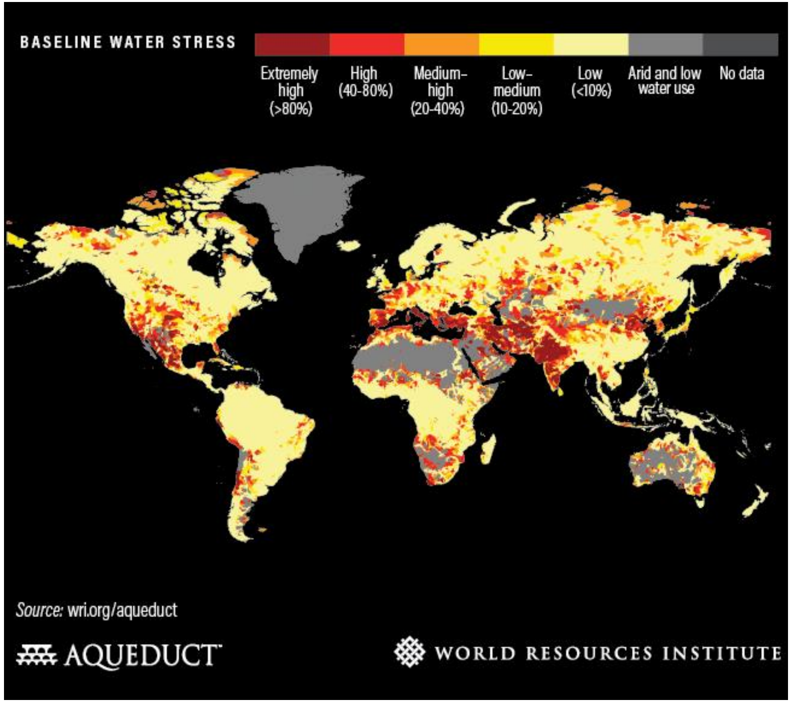
Water stress is an issue that will affect an increasingly large share of the world's population

Insights from the World Resources Institute's
Aqueduct Water Risk Atlas

- 17 countries, a quarter of the world's population, face "extremely high" water stress and **44 countries face "high" levels of water stress**
- Water stress is an **inherently local issue**: regions or communities located in countries with low overall water stress can still experience severely water-stressed conditions
- Global trends suggest that water stress **will worsen unless action is taken**: population growth and urbanization increase water demands, climate change makes precipitation more volatile and leads to lower water availability



Potential solutions to avoid competition for fresh and ground water in regions facing scarcity

Solution 1: Seawater desalination

- ＋ saline water is an **abundant resource in many regions**, and desalination provides freshwater to 300 million people
- ＋ **costs**: approximately **€0.001 per kg of desalinated water**
- ⚠ water from desalination currently has a **44 times higher CO_2 footprint than tap water** due to high amount of energy required
- ⚠ rejected **brine** can have significant **adverse environmental impacts**, e.g. causing significant damages to the local ecosystem when released into the sea

Solution 2: Water from Direct Air Capture (DAC)

- ＋ refers to low-temperature Direct Air Capture technology based on alkaline solid sorbents during which water is **extracted from ambient air** as a **by-product in the extraction of CO_2** (e.g. to produce carbon-based PtL fuels)
- ＋ up to **1 kg/kg of CO_2 captured**, i.e. ca. 3,8 kg per kg of PtL-fuel, can be drawn from the air, resulting in a **positive water balance:** more water is extracted than needed for fuels production
- ＋ extracting the respective amounts of water comes at **low additional costs**

Solution 3: Electrolysis of low-grade and saline water

- ＋ hydrogen production via electrolysis generally requires water in drinking quality
- ＋ **Research** ongoing on **electrolysers** capable of **operating directly** with **impure water feeds**, e.g. low-grade and saline water
- ⚠ **Has not reached commercial scale** yet; unclear which electrolyser technology will be most suitable for saline water

Fostering the environmental sustainability of water consumption: suggestions for criteria

Establishment of a **water consumption threshold**, e.g. of max. 50 kg per kg hydrogen output, cradle-to-grave

Implementation of a **plant-level, local water impact assessment**

When freshwater is used, the electrolyser **cannot be installed in areas with acute water scarcity**, measured by a two-year trend of facing "high" or "extremely high" water stress prior to the installation

An **ex-ante evaluation of the hydrological condition** of the construction site is to be conducted by the operator before the installation is implemented; to be audited within a certification process

The electrolyser must demonstrate **ex-ante that it does not increase the risk of declining water levels** or **negatively affect the existing water supply**

Fostering the environmental sustainability of water consumption: criteria for desalination

CO_2

GHG emissions associated with water desalination should be **counted towards the GHG emissions** of the produced **hydrogen**

The **environmental impact of the discharged brine** should be **minimised**:

- When brine is disposed into the sea in sensitive areas, **diffusers designed** to **maximize dilution** should be employed
- **Green antiscalants and green corrosion inhibitors** should be employed whenever possible as substitute to environmentally toxic alternatives
- **Brine should be processed to a larger extend than presently**, e.g. by implementing zero-discharge requirements

Guest speaker

Rivash Panday

Specialist – Sustainable Water
Sasol

Guest speaker

Luciana Mendes

Business Development Clean Tech
Alfa Laval

Q & A and Discussion

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Business Development Clean Tech
Alfa Laval

Jörg Baur

Senior Energy Expert
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

Thank you for your attention

powerfuels@dena.de
www.powerfuels.org

PROJECT TEAM

Strategic guidance

Andreas Kuhlann
Chief Executive,
Speaker of the Alliance

Christoph Jugel
Director,
Energy Systems

Stefan Siegemund
Director,
Sustainable Mobility & Altern. Energy Sources

Project Team

Kilian Crone
Team Lead
- Strategic positioning & Community building
- Content Development

Kim Lakeit
Expert
- Powerfuels Infrastructures
- Certification

Matteo Micheli
Expert
- Transportation & Aviation
- Energy System Modelling
- GHG emission assessment

Friederike Altgelt
Expert
- Road Transport
- EU Policy
- Sustainability criteria

Johanna Friese
Expert
- EU Policy
- Sustainability Criteria

Hannes Salomon
Expert
- Transportation & Shipping