“Green” water for green hydrogen

Keynote speech as part of the BOWE2H event

“Offshore wind and green hydrogen in Germany: national and transnational innovation

22 May 2023

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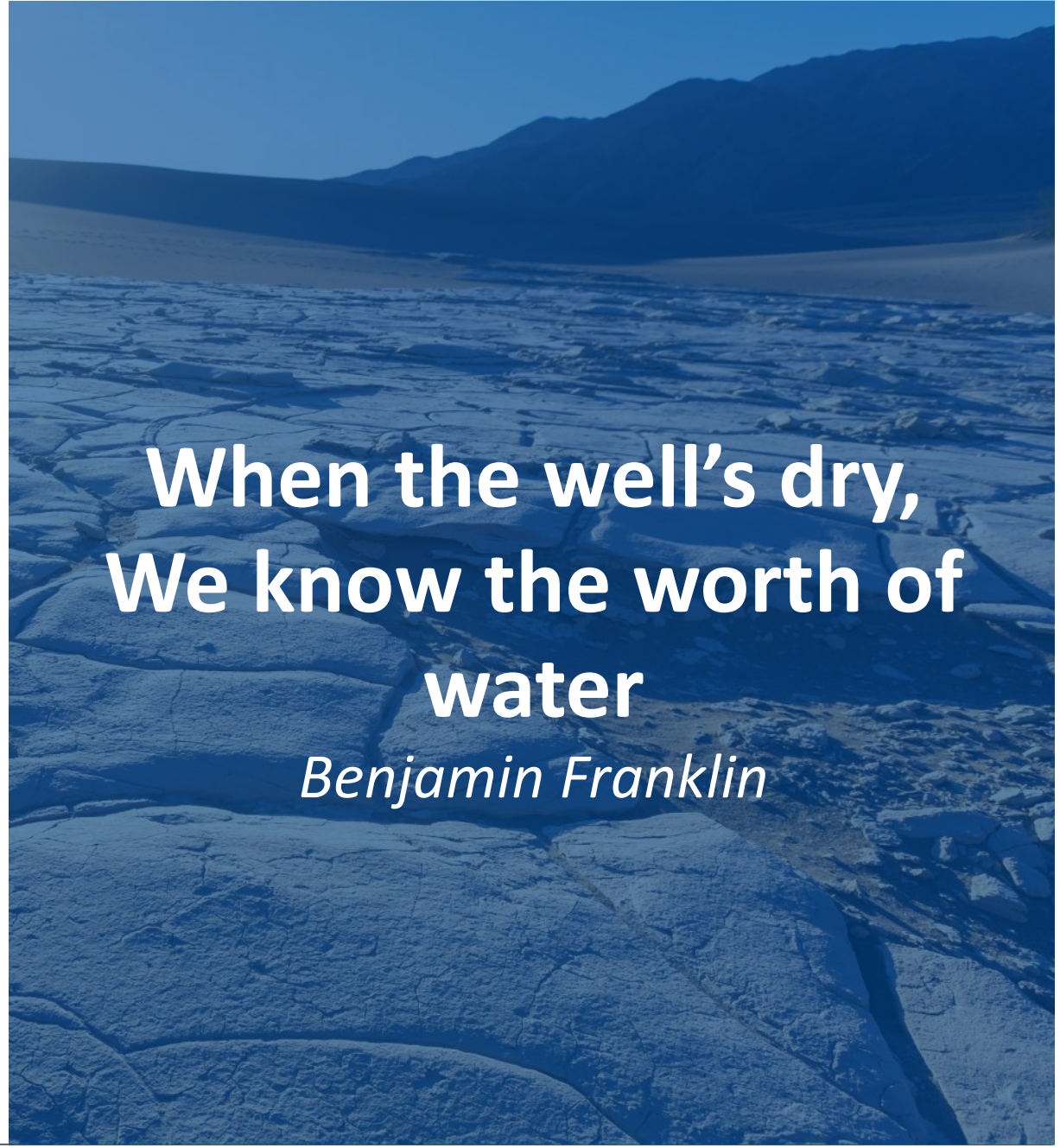
Taprogge

Agenda

1	TAPROGGE in general (3 slides)
2	TAPROGGE Terrawater Technology (2 slides)
3	Green water for green hydrogen (7 slides)



TAPROGGE GmbH
- a German medium-sized family business

For over 70 years, TAPROGGE has been engaged with the **optimization of large water circuits** in power plants, for desalination and cooling processes, and other industrial applications.

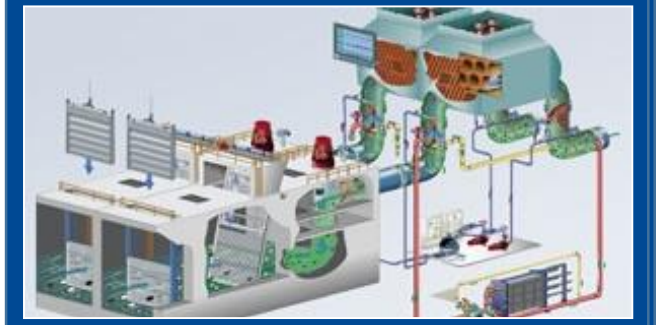
In this area of expertise, our process & plant engineering solutions make us a **global market leader.**

Established in	1953
Board of Management	Detlef Taprogge, Dr. Oliver Fröhling
Headquarters	Wetter (Ruhr), Deutschland
Number of employees	approx. 350 worldwide
Annual turnover	€ 60 Mio.
Share capital	€ 10 Mio.
Subsidiaries	China, Germany, France, Great Britain, Japan, Korea, Russia, Spain, USA, India
International agencies	in more than 60 countries around the world
Patents	more than 100 filed patents in the field of activity

Our core business applications

Specialized application and process technology to optimize large water circuits, with a focus on cooling water circuits and seawater desalination.

water intake



power plant – once-through cooling

seawater desalination (RO)

seawater desalination (thermal)

cleaning balls

TAPROGGE cleaning balls form the process-technological basis of our systems.
They allow us to prevent the formation of fouling and scaling in tubes by mechanical means, i.e. without using chemicals.

TAPIS® intake system for offshore applications

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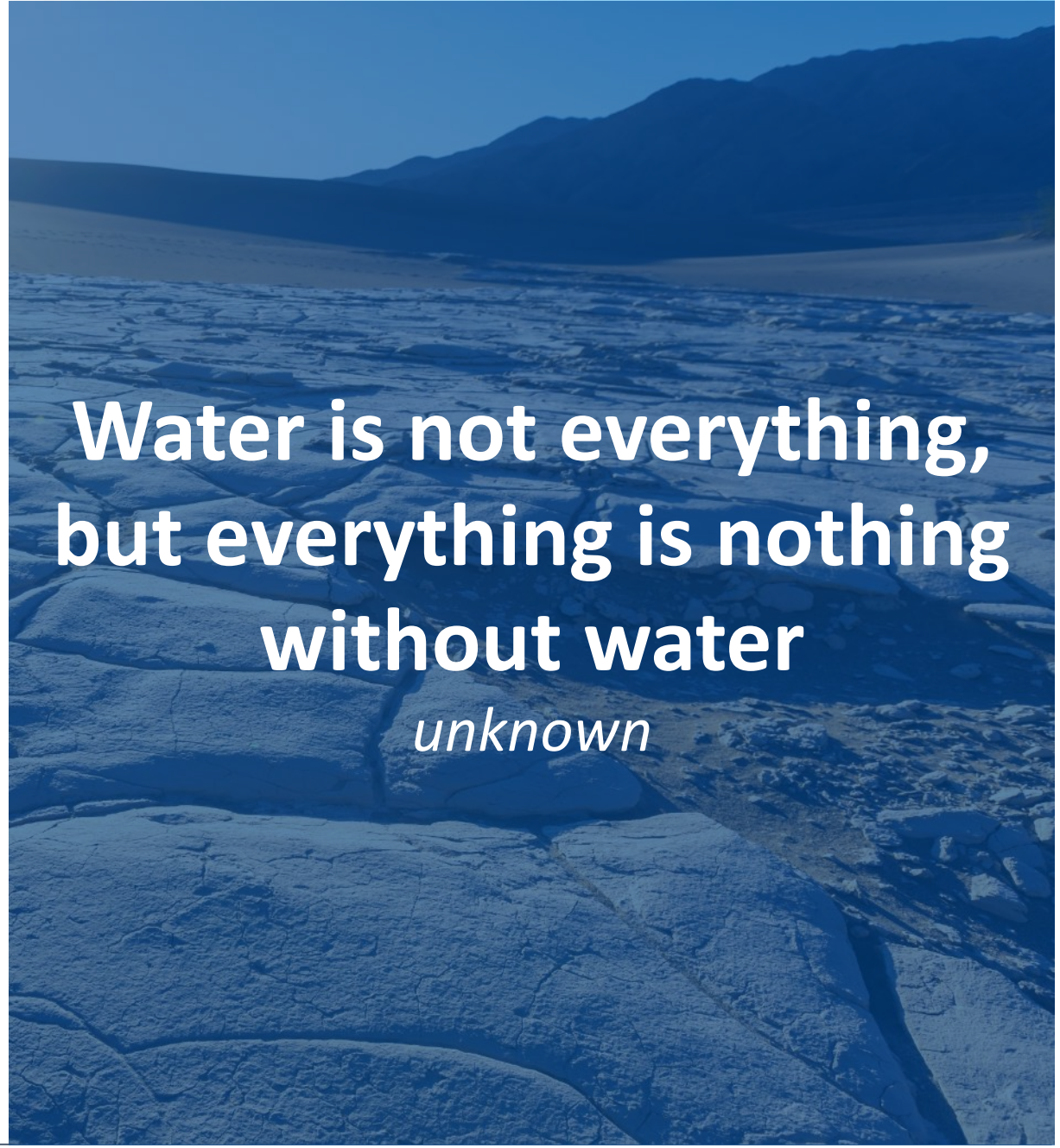


TAPROGGE Terrawater Technology - inspired by nature

TAPROGGE Terrawater Technology

- 2007 founded in Kiel, Germany
- specialized in **water desalination & reclamation of water, waste – concentration & recovery of resources**
- from **solar desalination** for drinking water to **resource extraction** (Sylter sea salt)
- and to **process water production** from seawater and waste water

YouTube, Channel „terrawater 1“

terra water TECHNOLOGY

The technology

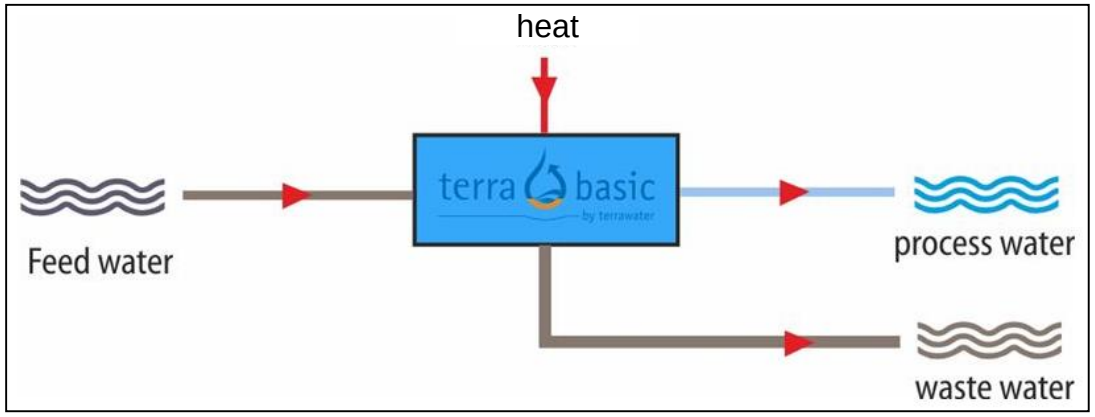
- is based on the natural principle of **evaporation** (<100° C, no vacuum, **no chemicals**)
- **uses waste heat** (cooling circuits of combined heat and power plants, electrolyzers, geothermal heat, solar heat, etc.)
- is made of **100% plastics** (no corrosion, long service life)

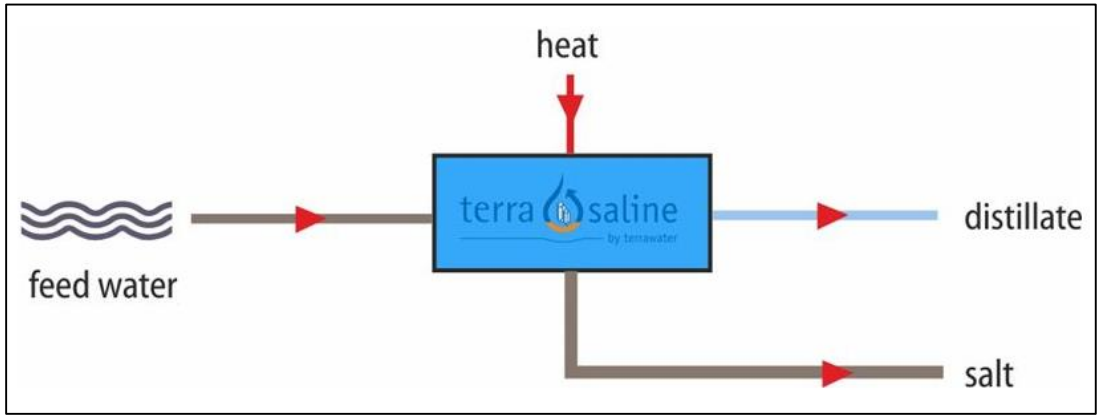
Taprogge

Terrawater Technology
thermal production of drinking water & high-purity water

Terrawater Technology = thermal desalination

- Salinity: any given concentration
- Recovery rate: min 10%, max 95% (ZLD)
- Conductivity of distillate: >2 < 10 µS/cm
- Quantity of distillate: modular, adapted to available heat
- No chemicals: eco-friendly
- Use of waste heat: increases efficiency
- Use of waste heat makes sense temperatures exceeding > 50° C
- No technicians needed: ideal for remote areas





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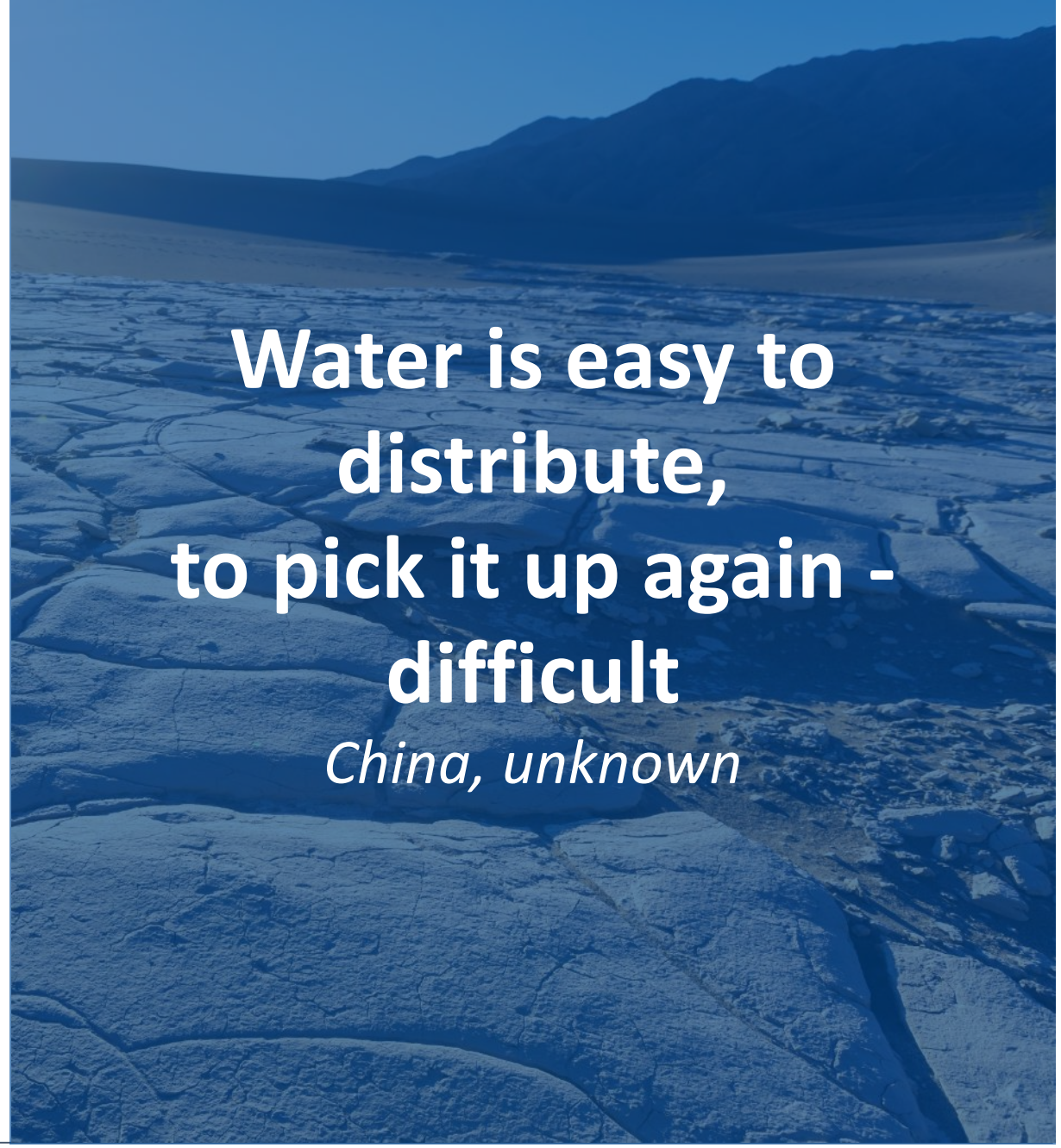

1. Which kind of water does an electrolyzer need?

- An electrolyzer needs ultra pure water. The “purity“ depends on the type of electrolysis used.
- General rule: “the purer – the better” (wear and/or service life of the stacks).
- In figures: in ideal settings, the conductivity is 0,1 µS/cm but max. 10 µS/cm (depending on the manufacturer).

  ➔ de-ionized water
- Until now, tap water has been used and treated. No problem with small on-shore electrolyzers.

  ➔ For off-shore applications, **water treatment** is required!

Ranking of the conductivity of typical waters (conductivity is a function of the temperature!):

North Sea	approx. 50.000 µS/cm
Baltic Sea	approx. 25.000 µS/cm
River water (Elbe)	up to 1,200 µS/cm
Tap water	500 – 1,000 µS/cm
Spring water	80 – 160 µS/cm
Rain water	30 µS/cm
Distillate for ironing	20 µS/cm
Elektrolysis	**0,1 – 10 µS/cm**
Boiler feed water	1 µS/cm

2. Which water treatment processes are appropriate?

Water treatment – simplified
raw water + **water treatment technology** = ultra pure water + residual water (**product water**) (**brine / retentate**)

➔ Water is not purified but pure **water is extracted** from the raw water!

➔ What remains are concentrates (brine) that have to be recirculated back to the raw water source.

- **Approx. 22 different water treatment technologies** (water desalination) exist, but only some of them are eligible for this use case.
- There are two classes of methods that are primarily used for **electrolysis**:
  - **membrane-based processes** (e.g. ultra-filtration (UF), reverse osmosis (RO)) or
  - **thermal processes** (e.g. membrane distillation (MD), multiple-effect distillation (MED), multiple-effect humidification (MEH))
- The above processes may be combined with or supported by other technologies (e.g. **ion exchanger**).

3. How much water does the electrolyzer need?

According to literature: 1 kg H_2 needs 9 kg distillate (according to manufacturers up to 15 kg).

➔ A **1 MWel** electrolyzer requires **per day a minimum of 6 m³** (based on 10 kg/H_2) **de-ionized water**!

This translates into the following matrix for the different capacities of electrolyzers:

Elektrolyzer in MWel	Elektrolyzer requires a **minimum** of [m³/day]	Raw water required (**minimum**) [m³/day]		Brine to be discharged (**minimum**) [m³/day]	
		for 50% brine	for 90% brine	for 50% brine	for 90% brine
1	6	12	60	6	54
10	60	120	600	60	540
50	300	600	3.000	300	2.700
100	600	1.200	6.000	600	5.400
1.000	6.000	12.000	60.000	6.000	54.000

Given the water volumes, it becomes obvious that the availability of raw water is an essential question.
Or rather the KEY question …

4. Membrane-based vs. thermal processes

The below “comparison“ has deliberately been reduced in complexity to outline the basic principles and differences for **North Sea** water.

Parameter	Membrane process (RO)	Thermal process (MEH)
Primary energy	electrical power	(waste)heat + electrical power
Water extracted by…	pressing	heating / condensing
Achievable conductivity in one stage (without additional technology)	500 µS/cm	>2 <10 µS/cm
Permanent anti-fouling, anti-scaling	yes	no
Concentration level of the brine	30% - 50% (realistic: 35%)	5% - 20%
Space requirements	low	medium - high

All technologies require intake systems / coarse filtration! RO requires an additional UF!

5. What makes water “green”?

“Green water“ is the designation for “terrestrial precipitation, evaporation and soil moisture“.

In technical terms it refers to the aspects of sustainability and environmental compatibility.

➔ Processes that produce water **as environmentally compatible as possible**, with a minimum of energy consumption and **without causing damage to nature** are producing “green water“.

The comparison of the two processes results in the following – simplified - matrix:

Green parameter	Filtration (RO)	Thermal (MEH)
Operating power	green electricity	waste heat electrolyzer increase in efficiency of the electrolyzer
Use of additives	yes, additives might be regarded as critical	no additives
Brine discharge	discharge into the sea possible, might cause discussions about additives	discharge into the sea possible; no discussion because free of additives
Brine concentration	up to 50%, might cause a – theoretical – discussion (critical if additives are used)	10% max., in the sea no measurable increase in concentration can be detected

6. On-shore electrolysis – additional challenges

When setting up on-shore electrolyzers, additional „green“ challenges are faced:

➔ Protection of drinking water reserves (regions with water scarcity)

➔ How to get rid of the brine? (Zero Liquid Discharge?)

To get a feel for the raw water consumption of an electrolyzer, the table shows the water demand of some German cities:

Electrolyzer Capacity	De-ionized water in m³/day (max)	Raw water demand in m³/day (max)	City	Water demand in m³/day (annual av.)	Inhabitants
10 MWel	72	720	XXX	0,13 (per Person)	5.600
100 MWel	720	7.200	Husum	7.000	22.000
400 MWel	2.880	28.800	Rostock	26.250	210.000
1.000 MWel	7.200	72.000	Düsseldorf	80.000	620.000
2.000 MWel	14.400	144.000			1.200.000

And on top: on-shore raw water sources are not always available:

Extreme drought in France in 2022 = nuclear power stations

Tagesschau on 10.08.2022

France: „Caught between climate change and nuclear power“

In France nuclear power stations are, given the gaz shortage, allowed to continue discharging cooling water into the already over-heated and low-water rivers, thus exceeding the defined limits. The daily paper Libération asked: “Stop the NPP or the salmon?"

Water scarcity in Germany

Tagesschau on 30.08.2022

Water scarcity in Germany: “An increasing threat"

In hundreds of German towns water is becoming a scarce. This is the outcome of a large-scale survey. Some regions have already imposed bans – especially the East of Germany is affected.

Whatever the nature of your raw water – our technology matches your needs

For all challenging tasks related to the water supply of electrolyzers
TAPROGGE is a one-stop-shop for customized technology.

Our end-to-end solutions include **intake systems**, **desalination processes** and **treatment of the brine (ZLD)**

Zero Liquid Discharge
separation of solids & water

Water from waste water
100% natural

extraction of

- cooling water
- drinking water
- process water

Resources from waste water
cost-effective

production of

- salts
- metals
- concentrates

Inspired by nature
economical

evaporation process

- chemical free
- CO_2 neutral
- sustainable

terra water TECHNOLOGY

terra basic by terrawater

terra precon by terrawater

terra saline by terrawater

terra organic by terrawater

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Get in touch – Stay in touch

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