→ Matthew Brannock

Challenges and opportunities for treatment of water for hydrogen production

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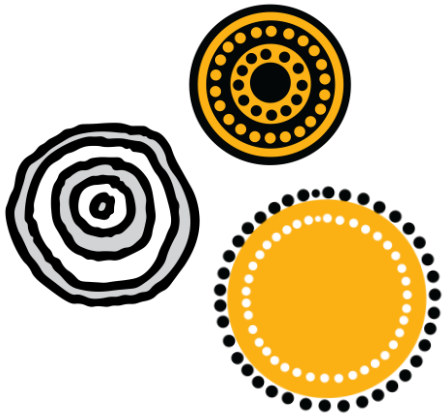
Welcome

Acknowledgement of Country

We are meeting online in various parts of the country, and I wish to acknowledge Aboriginal and Torres Strait Islander peoples as the traditional owners of the lands where we gather today.

I would like to pay my respect to their Elders, past, present and emerging, and extend that respect to other Aboriginal and Torres Strait Islander people who may be here today.



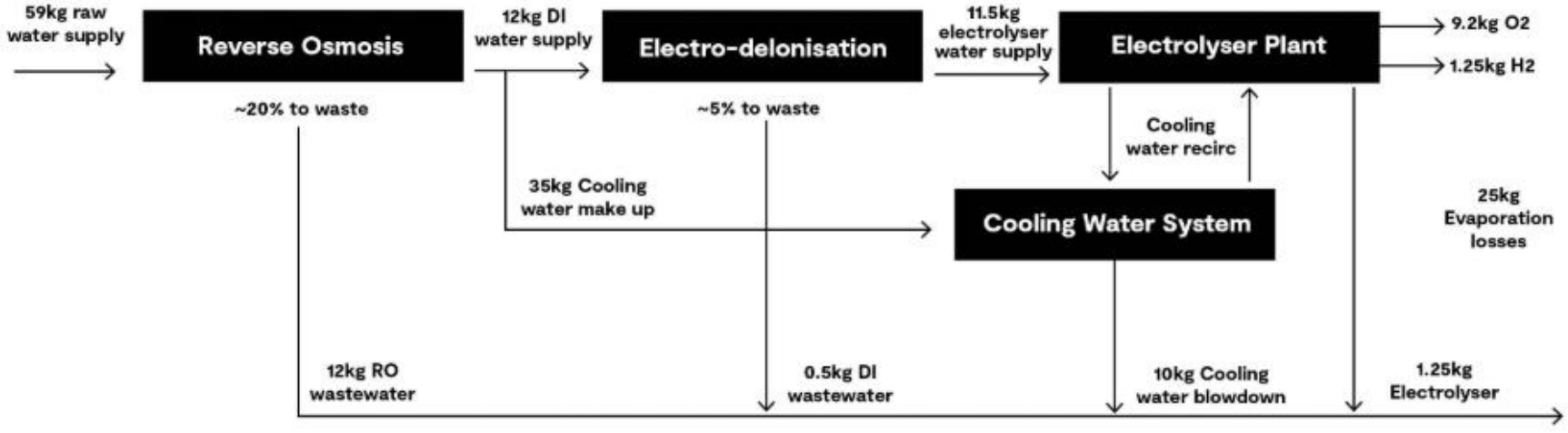
Overview

- Introduce H_2 production water streams:
  - Feed water for H_2 and cooling
  - Various waste streams
- Cover four real-world hydrogen projects:
  - Inland green hydrogen
  - Coastal green hydrogen
  - Inland blue hydrogen
  - Coastal blue hydrogen
- Summarise water treatment challenges and opportunities relating to H_2 production
- Project outcomes
- Conclusions

Water Requirements & Waste Streams – Green Hydrogen

- **Feed Water Streams:**
  - Hydrogen Production:
    - Dependent on technology
    - ~10-12 L demineralised water per kg H_2 produced
    - PEM Electrolyser: <0.25 ppm salinity, individual analytes <0.005 ppm (e.g. sodium, chloride)
  - Cooling Water Make-up:
    - 50-300% of electrolyser depending many variables
    - <500-1000 ppm salinity, low scale/biofouling potential, stable (i.e. pH buffered)
- **Waste Streams:**
  - Water treatment:
    - Dependent on water quality (raw, recycled & treated)
    - High solids streams, high salinity streams
    - Some readily recycled, some not
  - Hydrogen production:
    - Condensate from electrolyser & compressors
    - Small flows, relatively high quality

Example Schematic for Electrolyser Water Treatment based on Brackish Water Supply

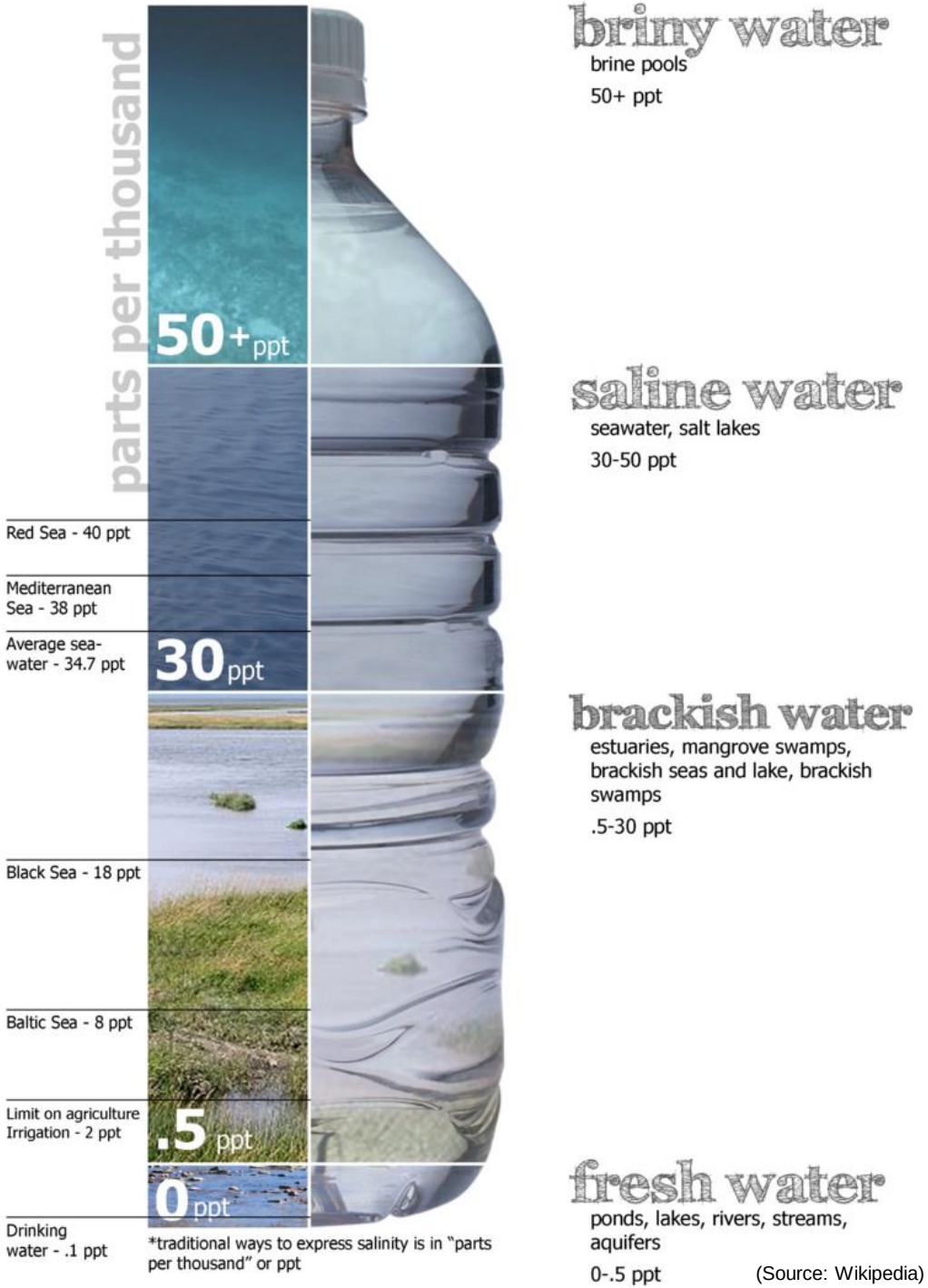


Water Requirements & Waste Streams – Blue Hydrogen

- **Feed Water Streams:**
  - Hydrogen Production:
    - Dependent on technology
    - ~3-8 L demineralised water per kg H_2 produced
    - Steam Methane Reforming: <0.5 ppm salinity, individual analytes <0.1 ppm (e.g. sodium, chloride)
  - Cooling Water Make-up:
    - Air cooling often used due to dry locations
    - May require adiabatic cooling → very high short water demands
- **Waste Streams:**
  - Water treatment related:
    - Dependent on water quality
    - High solids streams, high salinity streams
    - Some readily recycled, some not
  - Hydrogen production related:
    - Small to medium flows, various condensates (turbine, process, blowdown) some high in amines/organics

Project Examples

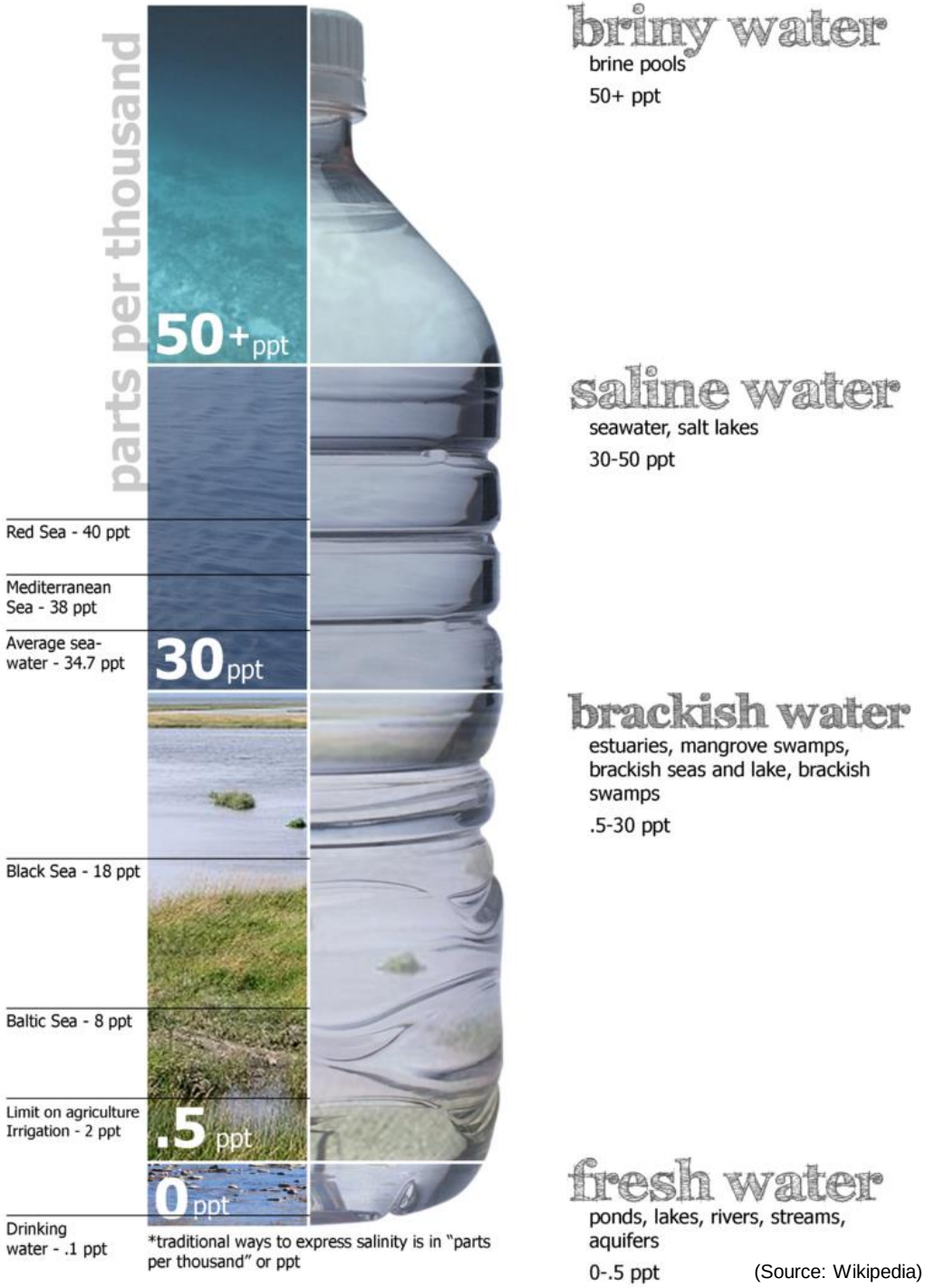
- **Green Hydrogen Inland:**
  - Int'l energy company client
  - Co-located with a windfarm
  - Located 50km inland in semi-arid location, some agriculture & townships nearby
  - *Brackish groundwater source (3,000 ppm salinity)*
- **Green Hydrogen Coastal:**
  - Multiple projects at same location, with and without NH_4
  - Wind & hydropower from grid
  - Coastal location on a river estuary, near population centres and agriculture
  - *Multiple pot'l water sources: Sea water, dam water, sewage effluent, saline estuary water (30,000 ppm salinity)*



(Source: Wikipedia)

Project Examples

- **Blue Hydrogen Inland:**
  - Oil and gas client
  - Located several 100kms inland, no agriculture or population centres nearby
  - *Brackish water groundwater (limited) & brackish produced water (water from oil/gas wells) (2,000-4,000 ppm salinity)*
- **Blue Hydrogen Coastal:**
  - Oil and gas client
  - Located at a relatively remote coastal location, small population centre nearby and not agriculture
  - *Sea water only available (40,000 ppm salinity)*

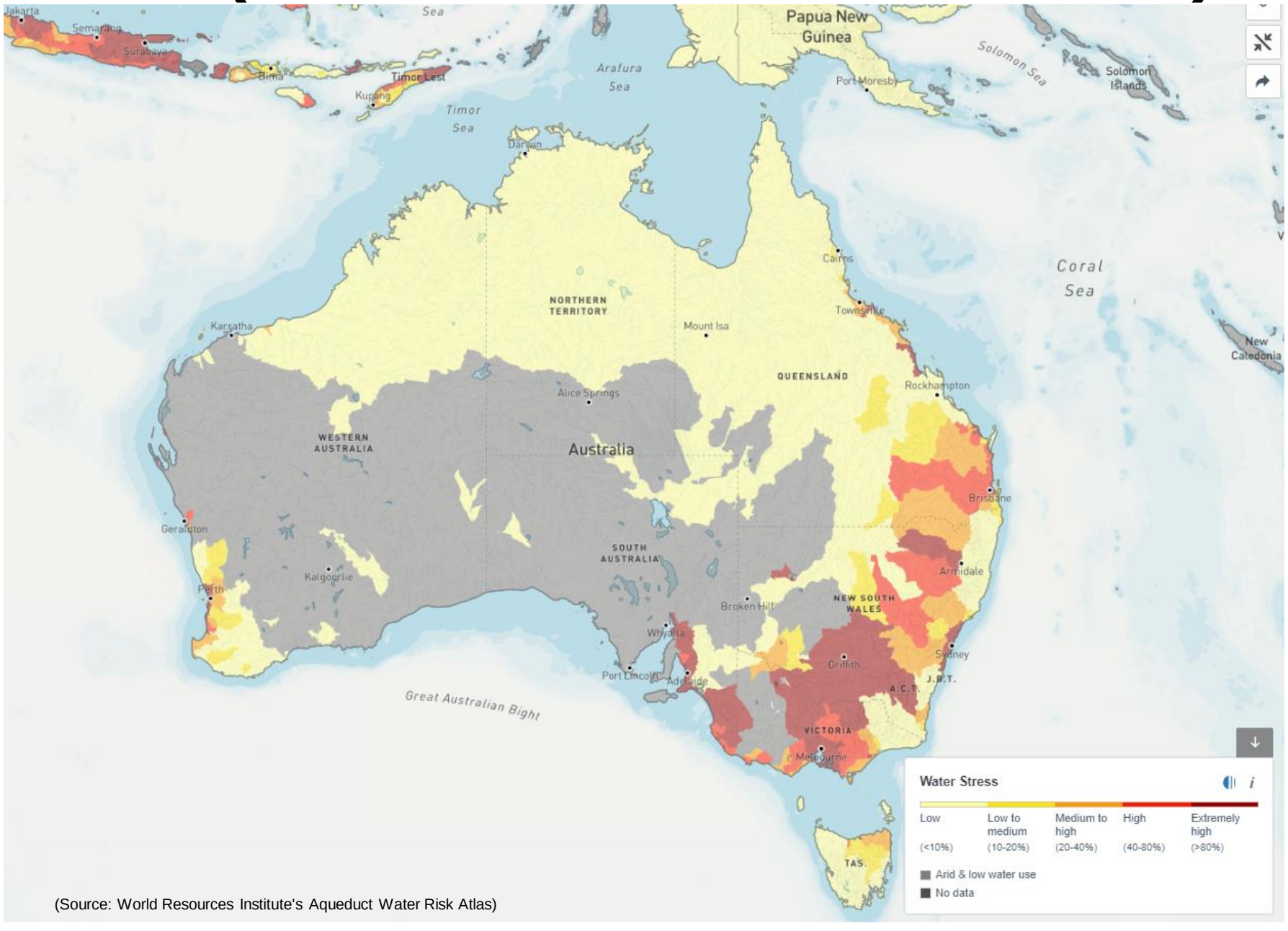


(Source: Wikipedia)

Water Treatment for H_2 Challenges and Opportunities

- **Challenge & Opportunity – Water Availability & Feed Water Chemistry:**
  - Projected H_2 exports water ≈ Australia's drinking water supply
  - Australia suffers water scarcity → Require new, challenging & more costly water
  - Regulations - water access, end uses & release of saline streams to environment
  - Cheap energy → hydrogen production & desalination → new water sources addressing water scarcity
- **Challenge & Opportunity – Location/Siting:**
  - Siting considerations for water sourcing – Water is heavy!
  - Cooling considerations (humidity, temperature etc)

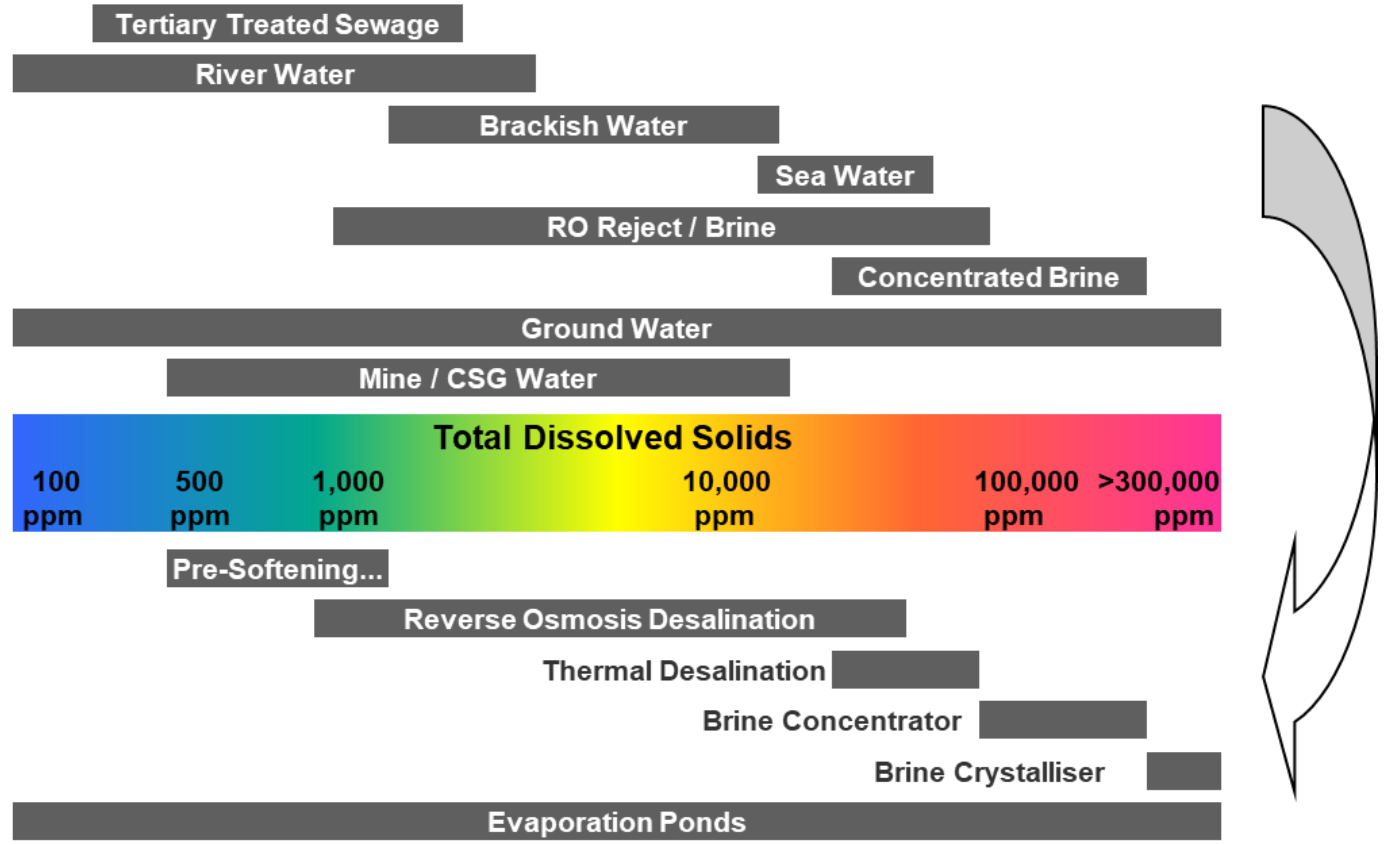
Water Stress (Demand vs Available Water)



(Source: World Resources Institute's Aqueduct Water Risk Atlas)

Water Treatment for H_2 Challenges and Opportunities

- **Challenge - Brine Management:**
  - H_2 water sources often brackish or saline → desalination
  - Management & disposal of desalination / salt waste – 50% water treatment cost if inland
  - Salt beneficial reuse
- **Challenge & Opportunity - Recycling of Waste Streams:**
  - Required at water constrained locations
  - Governed by water quality and volumes
  - Hydrogen production waste information often lacking in early phases



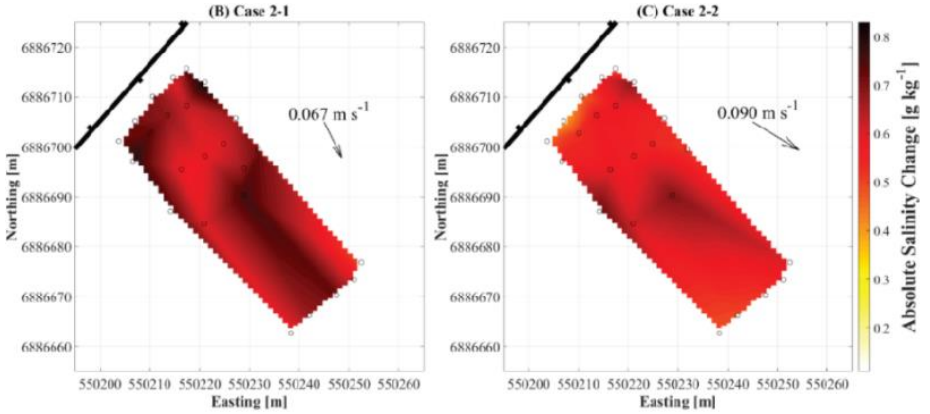
Water Treatment for H_2 Challenges and Opportunities

- **Challenges - Cooling Requirements:**
  - Site selection & local climate
  - Air vs water cooled
  - Seawater once through cooling vs seawater cooling tower
  - Adiabatic cooling at hot inland locations
- **Opportunity & Challenge - Waste Heat Recovery:**
  - Can drive desalination
  - Reduces cooling requirements
  - Creates a complicated system
- **Opportunity - Steam:**
  - Potential to use steam at blue hydrogen sites for thermal desalination (often expensive)
- **Opportunity - Oxygen Reuse:**
  - Enhanced oxidation for water pre-treatment
  - Enhanced aeration of nearby sewage treatment

Project Outcomes

- **Inland Green Hydrogen Project:**
  - Brackish groundwater desalination only option
  - Lack of source water quality / quantity information
  - Inland challenges for saline waste management
- **Coastal Green Hydrogen Project:**
  - Water availability constraints:
    - limited fresh water due to population / agriculture / industry
    - drawn out discussions with water suppliers/users
    - challenging alternative sources
  - Saline estuary water desalination shortlisted & discussions with surface water supplier ongoing
  - Regulatory requirements / investigations due to saline waste release to river estuary

Reverse Osmosis Desalination Array



Brine Dispersion Modelling

Project Outcomes

– **Inland Blue Hydrogen**
  - Numerous low quality water sources available (brackish ground water and produced water)
  - Some water sources 40km from WTP
  - Complex treatment due to requirement for desalination and hydrocarbons / oils in produced water

Coastal Blue Hydrogen:
  - Sea water only source available
  - Water quality samples >10 years old ∴resampling required
  - Regulatory hurdles & investigations due to saline water, waste, warm cooling water release

Project Outcomes

Project	Raw Water (L/kg H_2)	Waste Stream (% of Raw Water)	Cooling (% of Raw Water)	Demin for H2 &/or NH4 (% of Raw Water)
Inland Green H_2	16 (Brackish Ground Water)	28%	18%	65%
Coastal Green H_2+NH_4	117* (Saline Estuary Water)	65%	26%	9%
Inland Blue H_2 (Steam Methane Reforming)	13 (Brackish Ground & Produced Water)	38%	Air	62%
Inland Blue H_2 (Auto-Thermal Reactor)	5 (Brackish Ground & Produced Water)	37%	Air	63%
Coastal Blue H_2 (Steam Methane Reforming)	23 (Sea Water)	65%	Air or Sea Water	35%

* Additional water required for NH_4 production

Conclusion

- All projects have both common & scenario-specific challenges & opportunities
- Common challenges:
  - Water availability → difficult/saline water source → complex treatment + desalination
  - Waste stream management
  - Drawn out negotiations with water suppliers & regulatory hurdles
- Common opportunities:
  - Recycling of waste streams
  - Optimised cooling design to reduce water demand
  - Waste heat recovery
  - Enables supply of new water sources for community / industry
- **Water supply & treatment is integral for any H_2 project**
- **H_2 production can provide wider benefits (e.g. circular economy, new water supplies etc) however there are water-related challenges along the way**

Thank You

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