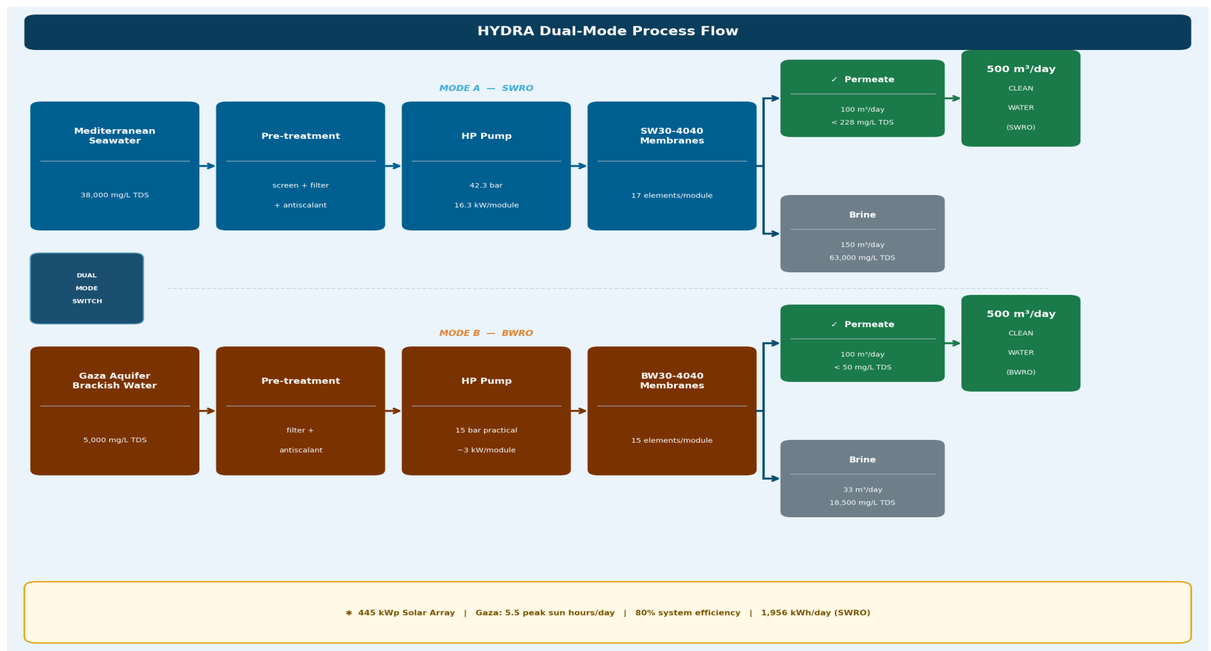
HYDRA: Scalable Solar Desalination for Humanitarian Water Security

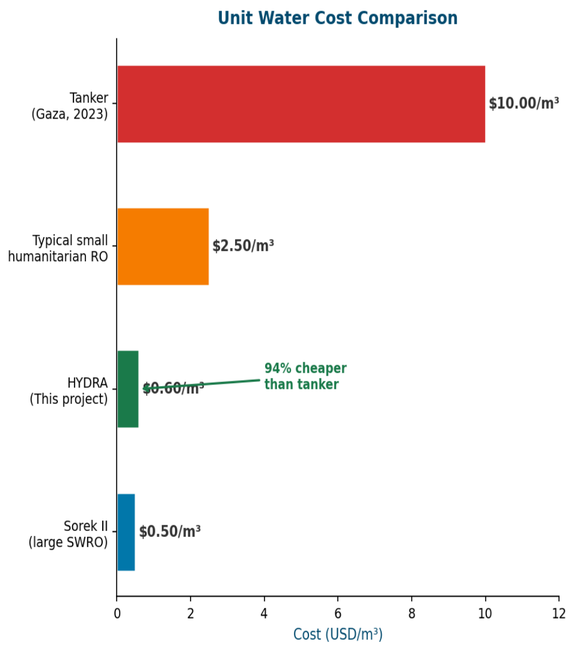
Ubaydullah Ahmed Russell McDonnell Abdulrahman Mohamud

Priority Topic Area: **Water and Sanitation**

1 – The Problem: Gaza's Water Crisis

Gaza has one of the world's worst water crises. Over 95% of the coastal aquifer is contaminated beyond WHO limits and the municipal network is largely destroyed. Residents pay USD 10/m^3 by tanker — 20x European rates — and an estimated 1 million people lack daily safe water access. Existing desalination plants require grid electricity, which is unavailable. HYDRA deploys five compact, solar-powered reverse osmosis modules, each transportable by flatbed truck, producing 500 m^3/day of WHO-compliant drinking water for 33,333 people at USD 0.60/m^3.





2 – Engineering Methodology

Mass & Energy Balance: SWRO (40% recovery) and BWRO (75% recovery) feed, permeate and concentrate flows modelled from van't Hoff osmotic pressure through pump power to specific energy consumption (kWh/m^3).

Solar Sizing: Daily energy divided by 5.5 peak sun hours at 80% system efficiency → 445 kWp required.

Scaling Risk: Langelier Saturation Index calculated for concentrate , HIGH in both modes (LSI >+2.0); antiscalant at 7 mg/L mandatory upstream of membranes.

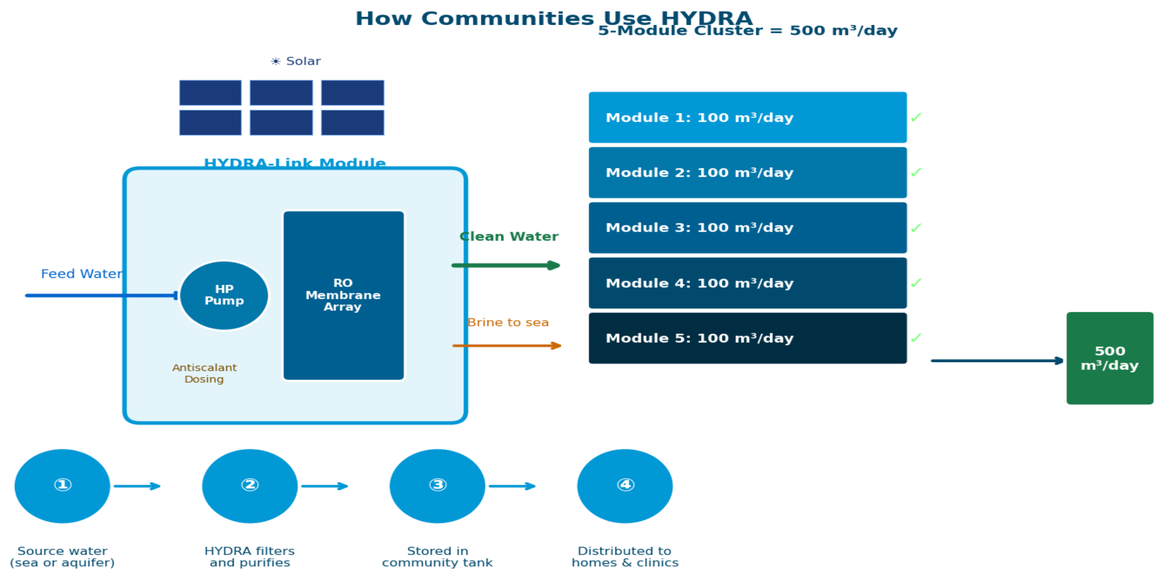
3 – Key Results

SWRO: 42.3 bar operating pressure | 16.30 kW/module | SEC 3.91 kWh/m^3 | 17 elements/module

BWRO: 15 bar | 1.50 kW/module | SEC 0.36 kWh/m^3 | 404 kWp surplus solar generation

Economics: CAPEX USD 595,674 | LCOW USD 0.60/m^3 | 94% cheaper than tanker | Saves USD 1.7M/year

Membrane rejection: 99.4% / 99.0% (SWRO/BWRO) | Scaling risk HIGH both modes (LSI +2.25/+2.42) — antiscalant mandatory



4 – Benefit to Society

HYDRA delivers life-critical water to 33,333 people/day at the WHO Sphere minimum of 15 L/person. At USD 0.60/m^3 versus USD 10/m^3 by tanker, it frees USD 1.7 million/year for food, medicine and shelter. Five independent modules eliminate any single point of failure. In BWRO mode, 404 kWp of surplus solar generation can power clinic refrigeration and mobile charging. The modular design is replicable, any conflict-affected coastal community can deploy one module at a time as funding allows, scaling to full capacity without interruption.

5 – Next Steps

① Brine disposal and diffuser design.

② Pre-treatment train specification.

③ Single-module pilot to verify model vs. field data.

④ HAZOP for conflict-zone operation.

References: IDA WC 2023; WHO GDWQ 4th ed.; Voutchkov, Desalination Engineering 2012; DuPont FilmTec SW30/BW30-4040 datasheets; Fritzmann et al., Desalination 221, 2007; Langelier JAWWA 1936; World Bank Solar Atlas; UN-Water Gaza 2022; BloombergNEF 2024; WHO/UNHCR Sphere Handbook 2018.