Solar-Driven Electrolysis of Agriculture Wastewater for the Production of Green Hydrogen

Group #91

Coach: Dr. Wasif Farooq Zameer

Mohammed Alfayadh –CHE | Saad Alajmi—CHE | Ziyad Aljarallah –ISE | Yazeed Alshammari -ISE

1. Project Statement

Utilizing solar-powered Proton Exchange Membrane (PEM) Electrolysis for Sustainable Green Hydrogen Production from Wastewater Treatment via Reverse Osmosis and Deionization Filtration.

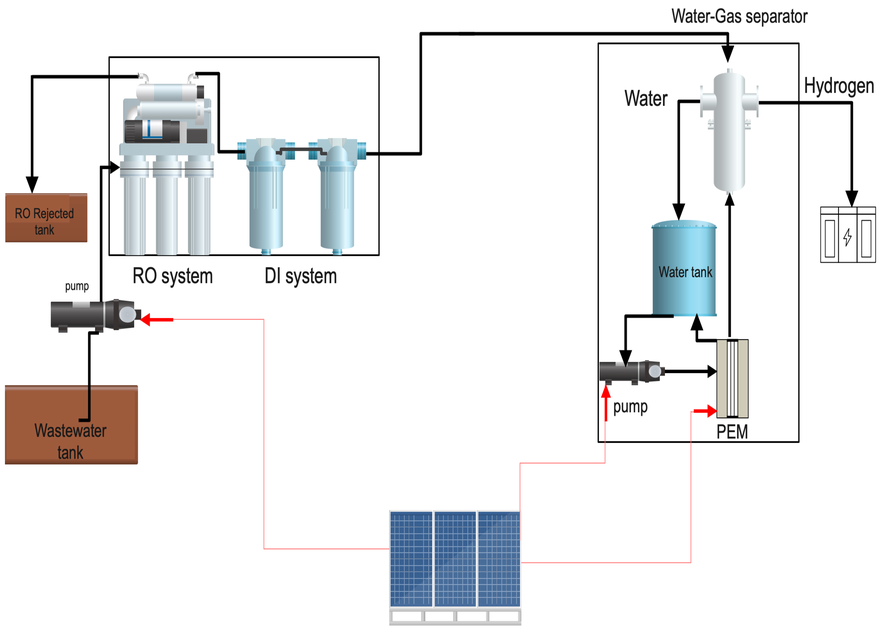
2. Constraints

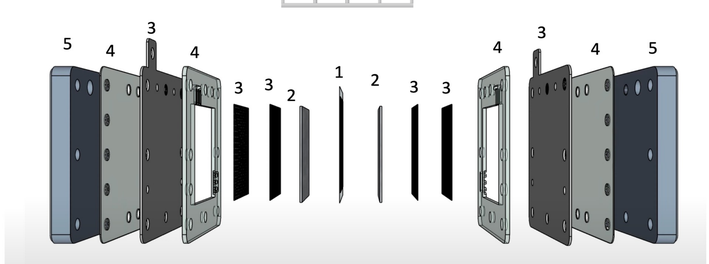
- Material selection
- Size of the units
- Location
- Water purity

3. Target Specifications

- pH for pure water is 6-7
- Solar power in the process is 180 W
- TDS of the water is approximately 0 ppm
- Water level in the system is 300 mL
- Conductivity of the water is 0 µS/cm
- Hydrogen volumetric flowrate is 300 mL/min

4. Prototype Final Design





1. PEM (Proton Exchange Membrane)
2. GDL (Gas Diffusion Layers)
3. Bipolar Plates (to match supply voltage)
4. Insulating rubber layer
5. Compression Plate

5. Mathematical Modeling Equations

$$\sum \Delta V_{cell}(T,p,I_{cell}) = V_{id} + \Delta V_{act} + \Delta V_{ohm} \quad (1)$$

$$V_{id} = \frac{\Delta G^{\circ}(T,p_{ref})}{nF} + \frac{RT}{nF} ln\left(\frac{p_{H_2}\, p_{O_2}^{0.5}}{a_{H_2O}}\right) \quad (2)$$

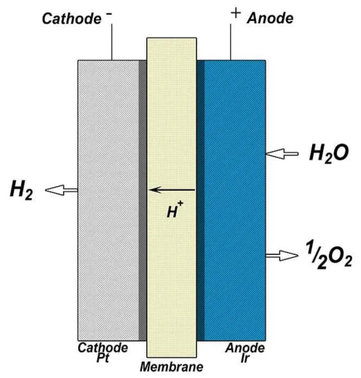
$$\Delta V_{act,X} = \frac{RT}{\alpha_X\, n\, F}\, ln\left(\frac{i_X}{i_{0,X}}\right) \quad (3)$$

$$\Delta V_{ohm} = (R_{electrodes} + R_{mem}) i_{useful} A \quad (4)$$

$$\dot{N}_{H_2O,cons} = \frac{I}{2F} \quad (5)$$

$$\dot{N}_{H_2,prod} = \frac{I}{2F} \quad (6)$$

$$\dot{N}_{O_2,prod} = \frac{I}{4F} \quad (7)$$

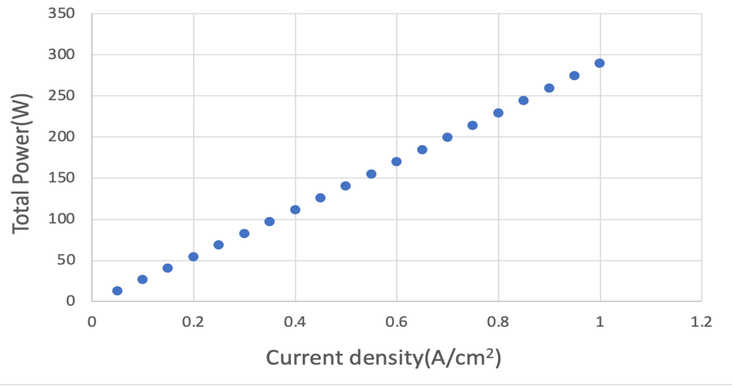


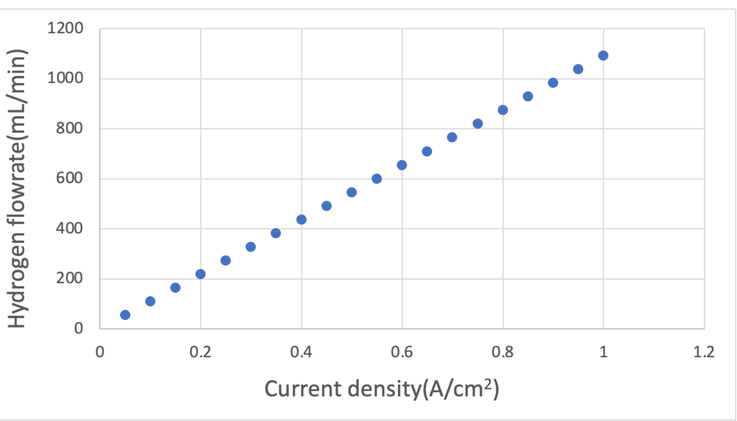
$H_2O \longrightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$ Anode

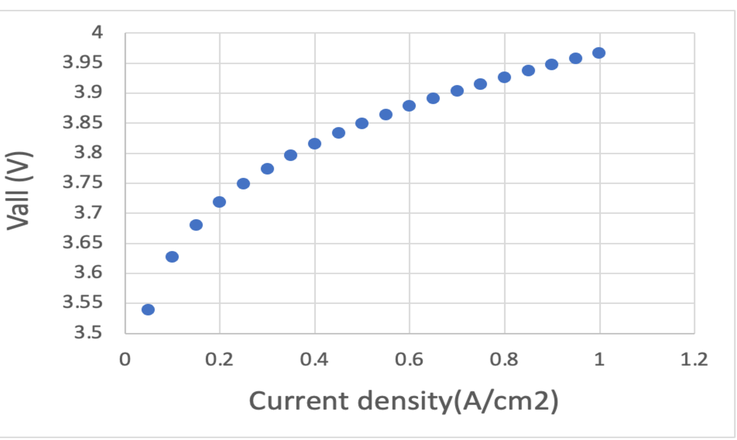
$2H^+ + 2e^- \longrightarrow H_2$ Cathode

$H_2O \longrightarrow H_2 + \frac{1}{2}O_2$ Total Reaction

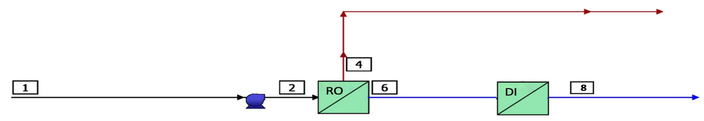
6. Results







7. Testing / Validation



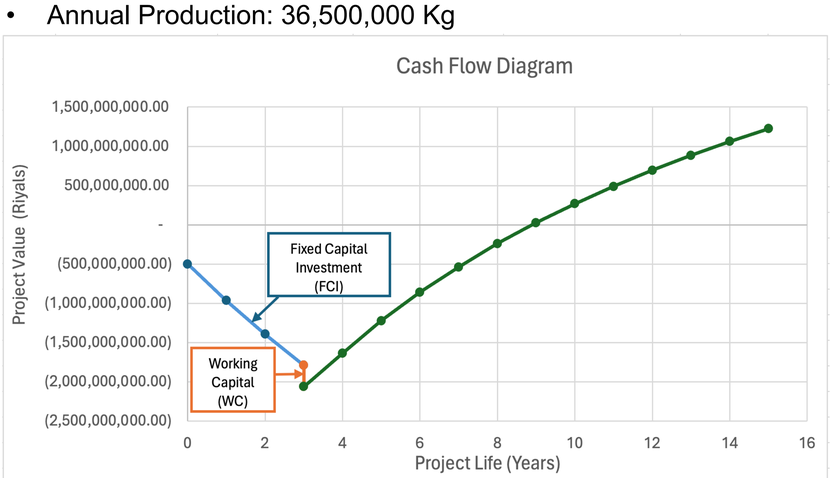
#	Description	Flow (mL/min)	TDS (ppm)	Pressure	Cond (µS/cm)	PH
1	Raw Feed to RO System	484.00	848.4	0.0	1532.0	6.1
2	Net Feed to RO System	484.00	848.6	2.7	1532.0	6.1
4	Rejected feed from RO System	121.00	1533.00	0.0	2670.00	6.3
6	Net Product from RO System	363.00	49.20	0.0	96.00	5.2
8	Net Product from DI System	363.00	0.002	0.0	0.055	7.0

H_2O Fed	363.00	mL/min
H_2 Produced	302.64	mL/min
H_2O Consumed	302.64	mL/min
H_2O Recycled	60.53	mL/min
O_2 Production	0.17	mL/min

8. Large Scale Economics

Economic Analysis:

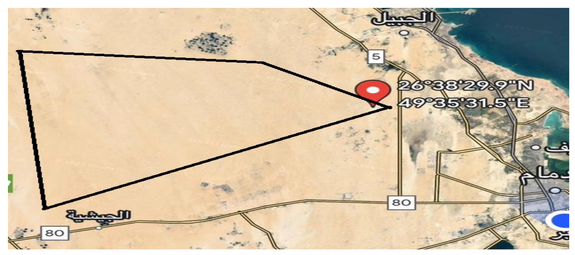
- Annual Production: 36,500,000 Kg



- H_2 Cost: 5.32 SAR/Kg | H_2 Price: 17 SAR/Kg
- NPV: 1,223,030,799 SAR

Facility location:

Selecting the optimal facility location for minimizing transportation costs for wastewater and green hydrogen. Analysis with Lingo software indicates Jubail as the ideal site. Annual transportation costs are 1,697,797 SAR for pipeline and 11,136,967 SAR for trucks.



9. Conclusions

Key Achievements: High water purity with zero TDS and Conductivity. Successful hydrogen production at a flow rate of 300 mL/min.

Project Goal: Efficiently produce green hydrogen from agricultural wastewater using solar-powered electrolysis.

Economic Viability: Affordable production with a payback period of 6 years.

Location Advantage: Chose Jubail for its industrial proximity, reducing transportation costs.