Waste ...
Effluent ...
NP is good to

All Inorganics

~~screen~~
primary Clarification — Rags

Activated sludge process

Air → CFSTR PFR → Clarifier
microbes → 2×3
physical separation
speedset
Filtration
cloth
~~disc~~ filters

Solid Waste
Disinfection
UV
NaCl (salt)

dissolved solids – NaCl (salt)

~~unit~~ waste water treatment

Municipal waste water
is ...

Good

RO

Weir → pulls water into plant
drinking water
unit process

Heart

Lake Houston
Coagulation flocculation

production of NH_3 methods?

Direct Air —

SOEC → ~~total~~ Energy — IN and OUT

H_2 — free electricity available → whats

Operating cost

Baseline process

LCOH

feasible

Electrodialysis.

- Human Health (carcinogen)
- Environment

~~Catch~~
Acidification

commu

Heat methods Desalination
cheaper

Thermal collectors.

Direct electrolysis

Baseline process..

Baseline approach

CCA for Haber process

MEB

wastewater

Electrical

(silicon) → cheaper

Solar

30

Photovoltaics
(absolute cells)

Renewable

Electrical

Thermal
&
...ity/Surge

Honeywell

Ammonia is stored in hydrides

&
Expensive

lanthanum hydrides

MFBC

q_{max}

$F_{ads,in}$

F_{WW} → $C_{HC,out}$ → $F_{ads,out}$

$C_{HC,in}$

$F_{ads,out} \approx F_{ads,in}$

F_{WW}: m^3/h or kg/h

HC conc $C_{HC,in}$ (mg/L)

q_{max}: Adsorption capacity (mg HC per g adsorbent)

0.5 g HC per g

$$F_{HC, adsorbed} = (C_{HC,in} - C_{HC,out}) F_{WW,in}$$

$1 m^3 = 264.17$ gallons

HAZOP study

$100 m^3/h$

→ 634,000 gallons/day water

→ Define volume water

1000 gpm

intake – $\boxed{2000 gpm}$

cost, schedule

~~120,000 gp~~ ~~280,000 gp~~

~~2~~ 2019

cost → OPEX → labour

CAPEX

1) chemicals

warranty.

GCWA

Gulf Coast Water Authority

$\boxed{\text{Texas city}}$

HB

W 340-500°C

150-300 bar

SOEC

700-800°C

1) TCEQ guidelines surface water x% (discharge point)

2) Deep well injection.

$\boxed{\text{Antiscalant, Brine corrosion inhibitors}}$

Prof. JB Powell

→ Microbial fuel cell
water

EI to E⊖

(Mineral Resource)

① CO_2-eq/FU: Measures the climate impact (how much it contributes to global warming)

① Cu-eq/FU: Measures resource use (how much it affects material availability)

Judging?

Idea 3:-

Photoelectrochemical → long term opt

350°C → Haber Bosch process: (850°C)

Echogen cycles
↓
natural gas

250°C - medium temp.
100°C - low temp.

AEM Alkaline electrolysers
Heat from HB process - ?

Energy

TEA :- electricity

Size of battery

0.6 power scaling rule

Life of electrodes

PAP - 1g (H+)
↓
NREL - ~~Aff~~ prototype
Colorado
test site

① H_2 - reactive, does not exists in free form. ② H_2 prod.
843 metric tons of CO_2 emission every year from fossil fuel

Fuel cell. Brown Hydrogen [(from coal)] – Gasification –

Grey hydrogen (3/4 of all H_2) [Natural gas] – steam methane reforming. –

Blue H_2:: [fossil fuels ⟶ carbon capture] — Sgas + steam.

③ H_2: used widely in oil refinery, steel Industry, methanol prod; Ammonia prod

High energy density

should be stored under high pressure

Storing e^- for short time: Battery

[California, Texas — so much electric renewable power on electric grid.]

Source
+ Mitsubishi Power
Magnum development
Utah

Electrolysers

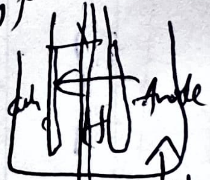
Polymer Electrolyte Membrane Electrolyzer (PEM)

Alkaline Electrolyzers

Solid Oxide Electrolyzers

→ Needs to have cheap electrolyzer

Enapter



H_2O

cathode: $4H^+ + 4e^- \rightarrow 2H_2$

Anode $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

Entropy.
(Green Energy Source for Green Hydrogen)

To do

① Compare H_2 power vs Nuclear Power. - why H_2 so imp?

② learn six sigma

Seawater or ocean water?

③ Yield?

④ Electrolysis - Electrolyzer?

JV · JV 0.00

$\frac{JV}{Vm^3}$ 1m³ = 1000 lit
= 1000 × 10³ ml

$\frac{JV}{V}$ m^3 (V) s^{-1}
(t) $J = \phi_0 \exp\left(\frac{-\Delta g}{RT}\right)$

$\frac{JV}{V - 1ml}$ × 10⁶ 10⁶ ml

1m³ = 10⁶ ml
1ml = 10⁻⁶ m³

Solar powerplants
PVPS - poly electrolyte

pictures.
Bad numbers

Haber Bosch plant Haldor-Topsoe

Cumulative SOP
→ community impacts - people lives close by - sustainability

Additional
Additional cost? vs
Additional sustainable
→ environmental cost?
(5) short term vs mid term vs long term
Renewable cost ↓
Time
cost of electrolyzer ↓

& Baytown (west texas)
↓
solar gen

(2) Our operations
MFC with Integrate RO to SOEC
Add some blocks

(3) photo electrochemical water splitting.
+ Add additional units

(6) Calculation of solar & wind at the site

(4) CAPEX OPEX/kW = $\frac{CAPEX + OPEX}{\text{Prod. rate}}$ = MSP (Min. selling Price)

Estimate number for Energy Consumptions → Estimate carbon emissions
EPA (Environ protection Agency) - Texas some numbers for CO₂ from energy mix

Alkaline Electrolysis - 30 bar pressure

STEP 1 minimizing cost of electrolyzer

↳ cost effectiveness

capital cost

electricity

cost of electricity from Renewable Energy sources

Literature review

[Technical → economically → environmental] ① cost of Alkaline

Techno-economic analysis.

→ MFC-numbers in Texas.

RO - cost

{ CAPEX
OPEX

Alkaline water electrolysis: commercial!

② Technology commercial scale ??
novel technology

Technical Analysis

- PEM - most researchers

Solar/wind :- no emission

Step 2: RO
→ cost of RO?

Energy mix :- Carbon emission from coal

Texas grid natural gas, solar & wind

natural gas →

Paper - RO

primary, secondary; tertiary stage water

electricity to RO from Renewable

Blue H_2

Technical Assessment

2 scenario: 100% Renewable to produce Green H_2

Elect from Grid - Blue H_2 of Texas

Energy Balance

IDEA 1: MFC → RO → Alkaline $\xrightarrow{H_2}$ HB
electrode-type 1
Heatstore
Urban house bldg
PCM

IDEA-2. COA Analysis LCA

In

~~MF.~~ MFC → RO → SOFC → HB
Electrode charge types-1 & 2
waste heat

Cost Analysis

LCA

IDEA-3

Chitosan → ~~RO.~~ ~~SOFC~~ Alkaline → HB
Electrode type-2
PCM

Cost Analysis
LCA

MFC → chitosan → RO → SOFC → HB
out

Anoop's LCA
Energy cost + operating cost

80% of water is thrown out

RO is expensive –
Energy consumption is very high

(ENERIN Norway
HOEG Temp.)
250°C

Energy Budget
Water Budget

wastage per every gallon

(Honeywell)
& Elride
(800-900°C)

water desalination

waste-water :- Sensors

Heatpump-200°C

{compression} – Max-temp – $S\text{-}CO_2$: 500°C
GE

Hysys model - ONLINE

1. Models -
2. Ansys model - Prototype
3. First principles

NREL, NETL, PNNL

- Baseline model -

IDEA-1:

Air ↓

DES

MFC → Activated sludge → SOEC → HB

HB → SOEC

IDEA-2:

~~MFC~~ → RO → AE → HB → PCM →

Activated sludge process → RO →

Heat storage → PCM

0.3-0.6 kWh, 3-5 kWh 50 kWh/H_2

IDEA-3:

Air ↓

NHDC → SOEC → HB

HB → SOEC

SOEC → diff materials

De : Life Cycle Assesment

SOEC, PEMEC

-16 impact catgories

Alkaline electrolysis : 60-90°C, nickel, stainless steel

PEM : 50-100°C : High power density, platinum

SOEC : 600-900°C due to favorable kinetics

SOEC : - built on oxygen conducting solid ceramic membranes

Oxygen electrode
Electrolyte
Hydrogen electrolyte
Interconnect
Frame

Perfluoro sulfonic acid (PFSA) - Nafion membrane

Copolymers : Tetrafluoroethylene + florinated vinyl ether

T

Perovskite solar cells :

electrode matg?

Electr storage

Electrolyzer

Electrolysis

Lifecycle Assessment?
↳ software

Euro Eco indicator 99
↳ 9 diff factors

10 pounds steel

LCA - Harm factors

tools free?

Ulm Dichem Eqn

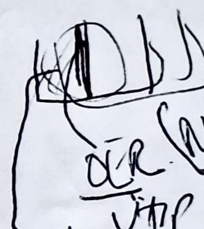
Catalyst

LCA for solar
collectors
or carbon composites

Entire plant

(1) General Atomics

Neelamma OER OER surface energy feed



to maintain
electrolyte pH

adsorption

too weak

OER
VHP
Adsorption

NiOOH

bifunctional

Pt Ruthenium oxide

1) Goal

PEM, AEM, solid oxide

Energy

nuclear power

Cells

→ Green Ammonia going to Japan

US govt hydrogen effort
↳ January

→ [Ammonia + Electrolyzer -
Electrochemical RAD, solid oxide electrolyzers. Gr.] solid oxide Ele

→ Wind is fluctuating + data science. Idaho labs.
Intermittency PNNL - Oldham arena

Links - simple science experiment (bubbles?) NaCl

Solar, wind. intermittance - so bad - lowers the efficiency of electrolyzer E (diano)

ECR

F-72 / 180 = C-0 / 100

Anupji

cata

(1) Thermal Decomposition of water at higher temp.

conc H_2SO_4 - 500°C - SO_2 - H_2O

closed loop system.

Westinghouse process at 800°C

Decompose H_2 to O_2

solar heat difficult - 500°C is possible

catalysts - reduce chemical

(2) Using waste water → Fuel cell

Reverse Osmosis - expensive

Membrane - ΔP - require

water desalination - top effect evaporators. 70-80°C

thermal collector to purify water

photovoltaic devices

· ~~perov~~ that combine multiple layers of light absorbing materials.

- perovskite-silicon tandems.

- (Photovoltaic) High temp's

Efficiency solar cells.

GaAs Cadmium cells? cost??

silicon - efficient efficiency

Cadmium cells higher

Tandem cells - efficiency

↓ at 80°C lower temp, better perform

Thermal collector.

Plant

2 pounds - day

Turbine. Use H_2 - store & electricity

1 pond for supply line

1 pond of salt to electrolysis

carbon-composite tanks - with lightstand pressure - store H_2

carbon

light weight

long fiber composites

stainless steel - expensive

Adda

$\frac{2}{5}$ $\frac{1}{6}$

5 ± 1

0.4 1

6 ± 2

$7 \pm$

0.00014

$1.4 \times 10^{-4} \times 10^{-1} \times 10$

140×10^{-5}

I 4.9×10^{-8}

II 140×10^{-5}

III 8.9×10

I > II > III