

Energy Transitions and Systems

Safety considerations of Building Green Hydrogen Manufacturing and Storage System



About Speaker

- Anil Relan is Vice President for Jacobs' Life Sciences, Industrial Segment including Green Hydrogen of Energy & Power Portfolio, EV & Batteries, Semiconductor, Data Centers and Specialized Manufacturing for India and Life Sciences for APAC . With significant design and construction management experience globally , Anil's 28-year tenure at Jacobs includes oversight and execution of large-scale, fast-track, life sciences and Industrial Projects. . Anil Graduated from Punjab University with a degree in Chemical Engineering & Post Graduate Diploma in Management



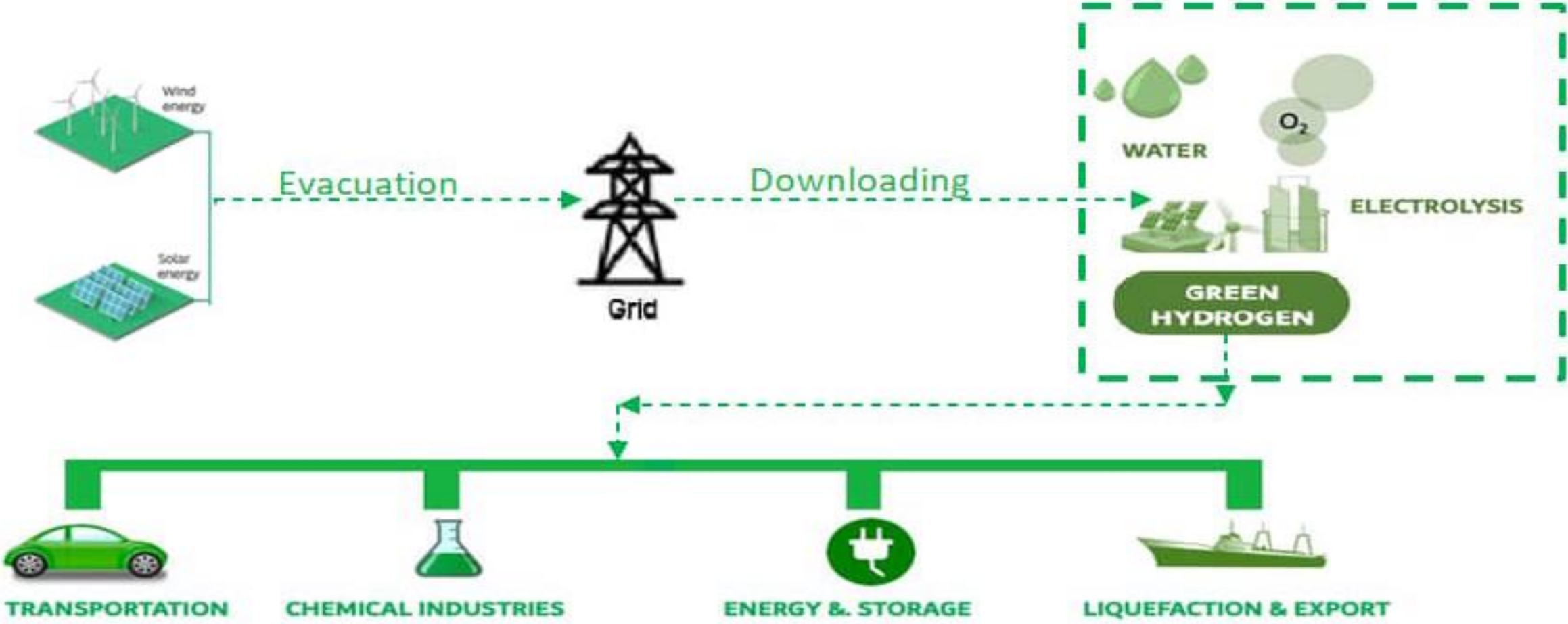
Green Hydrogen – Definition

- “Green Hydrogen” shall mean Hydrogen produced using renewable energy, including, but not limited to, production through electrolysis or conversion of Biomass. Renewable energy also includes such electricity generated from renewable sources which is stored in an energy storage system or banked with the grid in accordance with applicable regulations

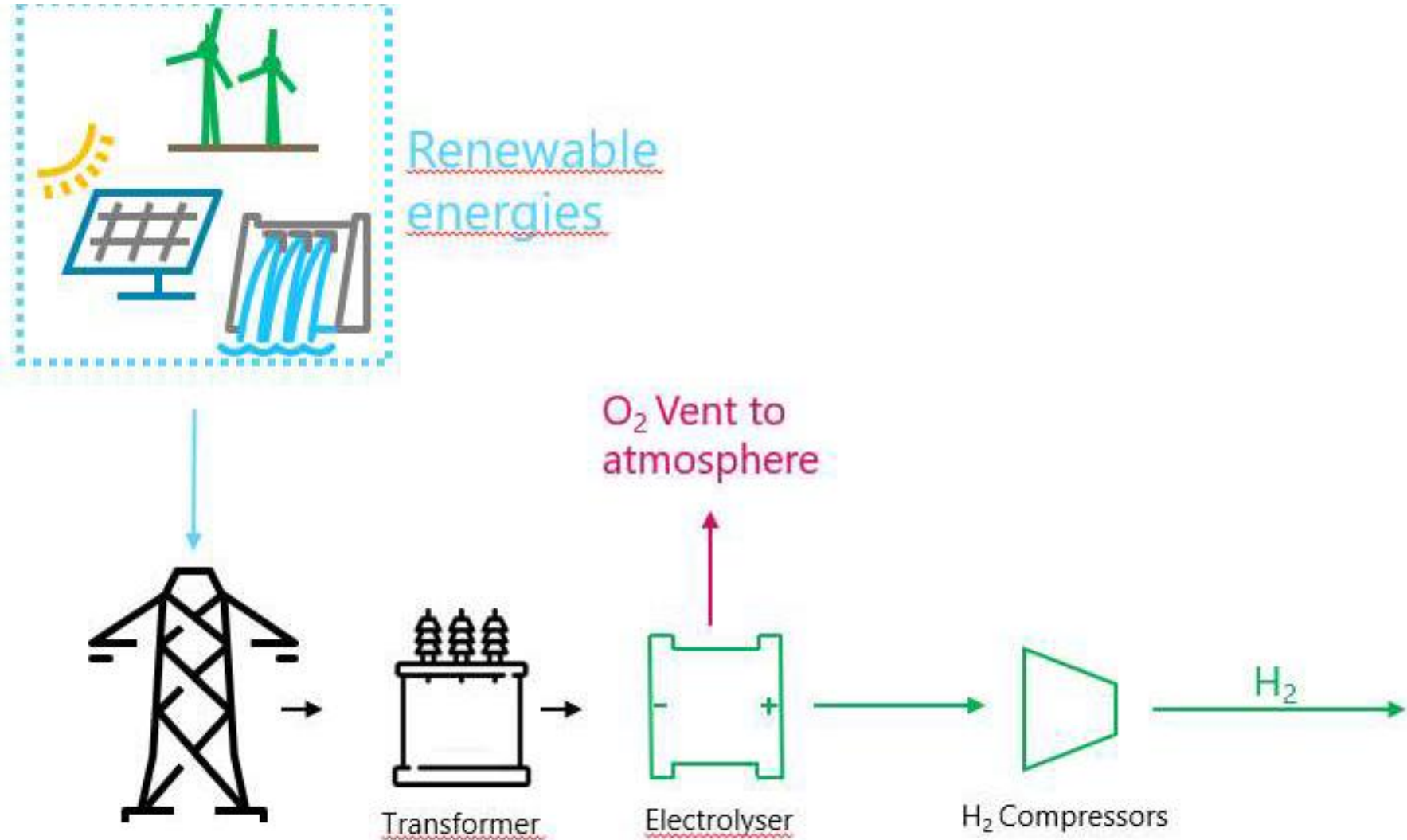
Whereas, for Green Hydrogen produced through electrolysis:

- The non biogenic greenhouse gas emissions arising from water treatment, electrolysis, gas purification and drying and compression of Hydrogen shall not be greater than 2 Kilogram of Carbon dioxide equivalent per kilogram of Hydrogen, taken as an average over last 12 month period of electricity generated from Renewable system or banked with the grid in accordance with applicable regulations

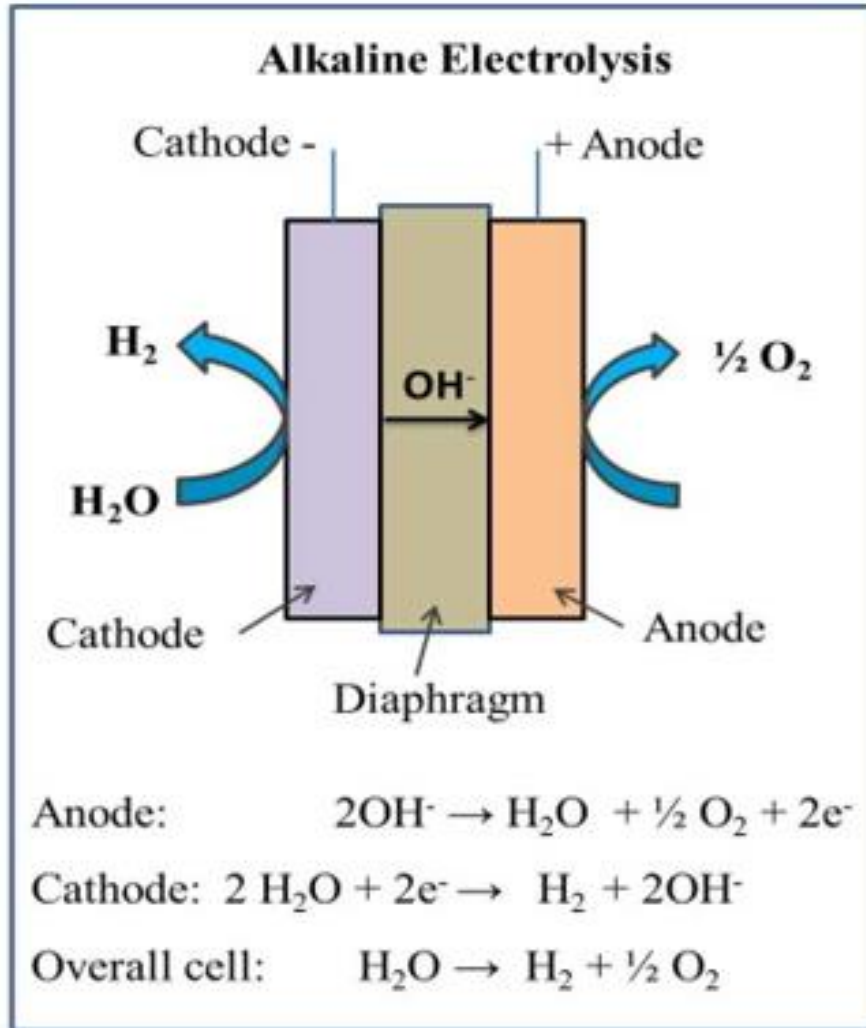
Green Hydrogen – Echo System



Generic Scheme for Industrial use of Green Hydrogen



Technology Options- Alkaline Electrolysis



Pros

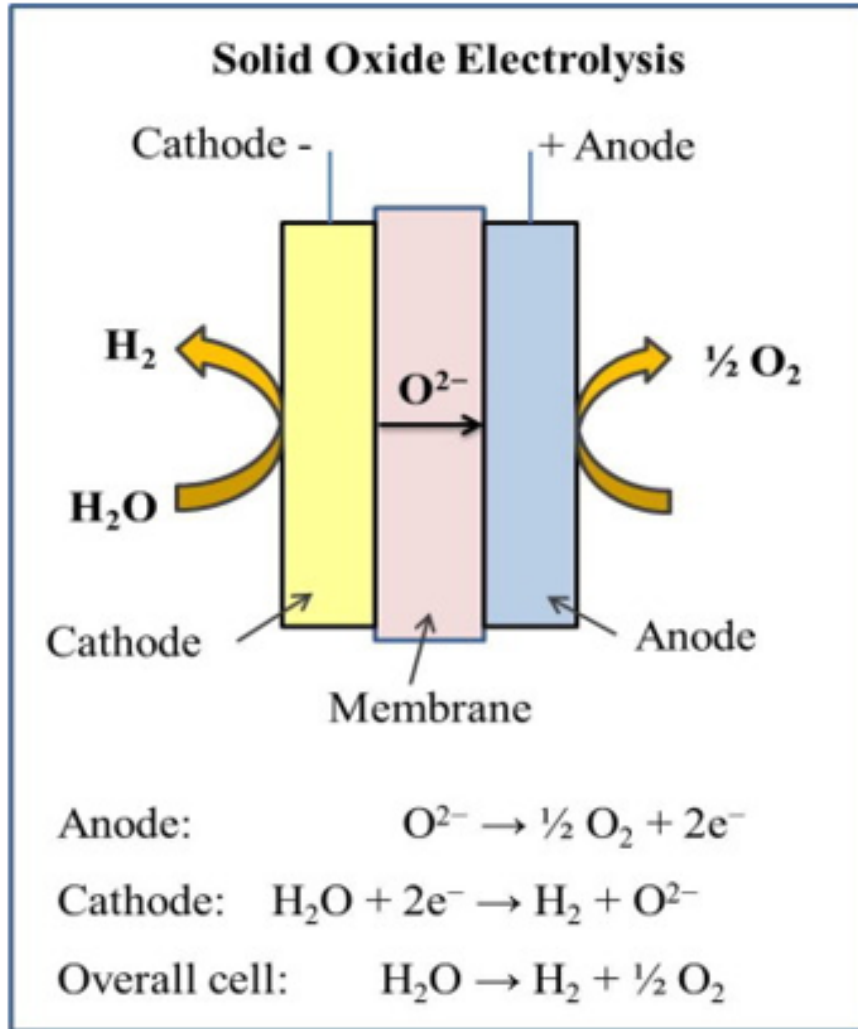
- ✓ Commercially scaled
- ✓ Mature Technology
- ✓ Low Capital Cost
- ✓ Low operating cost

Cons

- ✗ High operational complexity (liquid electrolyte solution)
- ✗ Low current density
- ✗ Corrosion prone



Technology Options – Solid Oxide Electrolysis



Pros

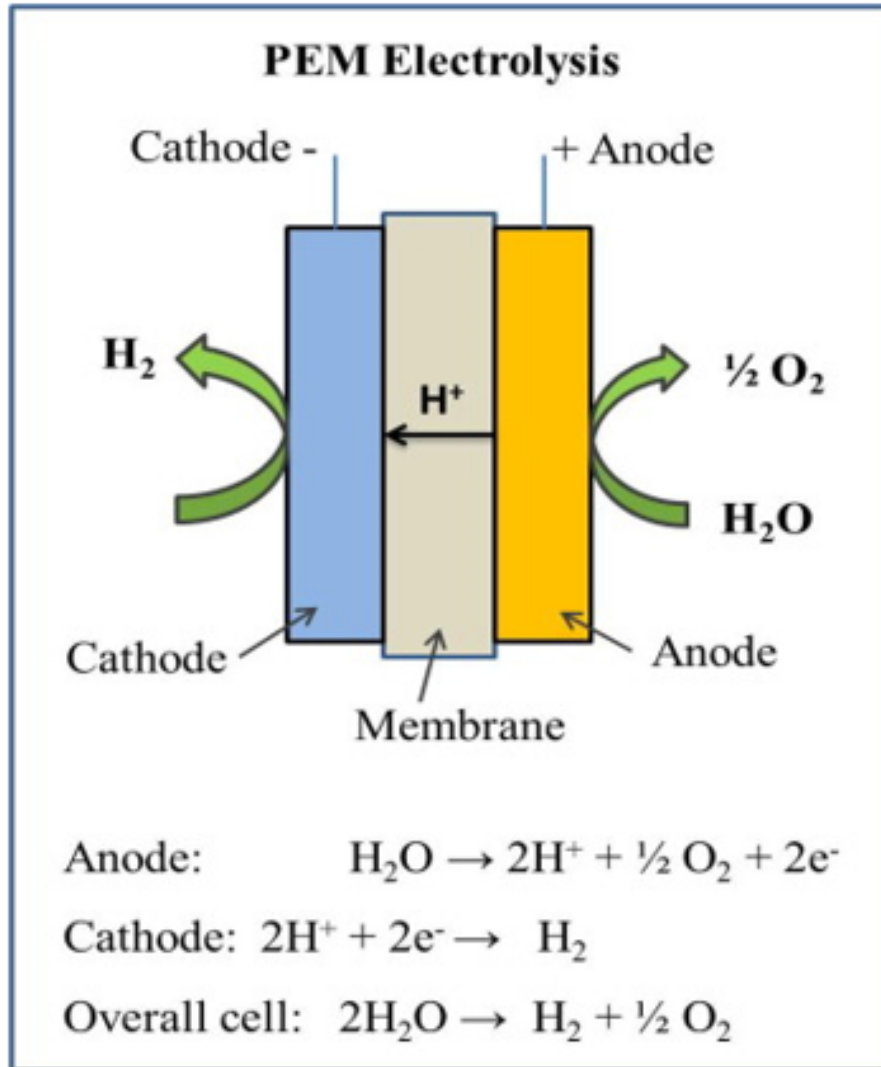
- ✓ Highest efficiency
- ✓ Low operational complexity
(*solid electrolyte membrane*)
- ✓ High current density

Cons

- ✗ Least developed at scale
- ✗ High capital cost
- ✗ High maintenance cost



Technology Options - PEM Electrolysis



Pros

- ✓ High efficiency
- ✓ Fast and precise turndown ability
- ✓ Low operational complexity (*solid electrolyte membrane*)
- ✓ High current density

Cons

- ✗ Relatively less developed at scale
- ✗ Moderate capital cost
- ✗ High maintenance cost



Storage, Transportation Systems and requirements

- Hydrogen standard transport quality standards (e.g ISO 14687:2020)
- The compression system would need to be set up to the required pressure for the tube trailers used to transport the hydrogen offsite
- Capacity of tube trailer 300Kg to 1000Kg (normally 500 Kg)
- Adopt regulatory safety standards for ATEX and hazardous areas
- Hazardous Area Classification Zone 1 Group 2C
- For 100 MW plant, 2 Tons two tube type storage system at 500 bar are considered (range is 350 to 700 bar) .
- Requires COMAH regulations to be complied to in UK & PESO (Petroleum and Explosive Organization, Gas Storage Rules 2016) in India

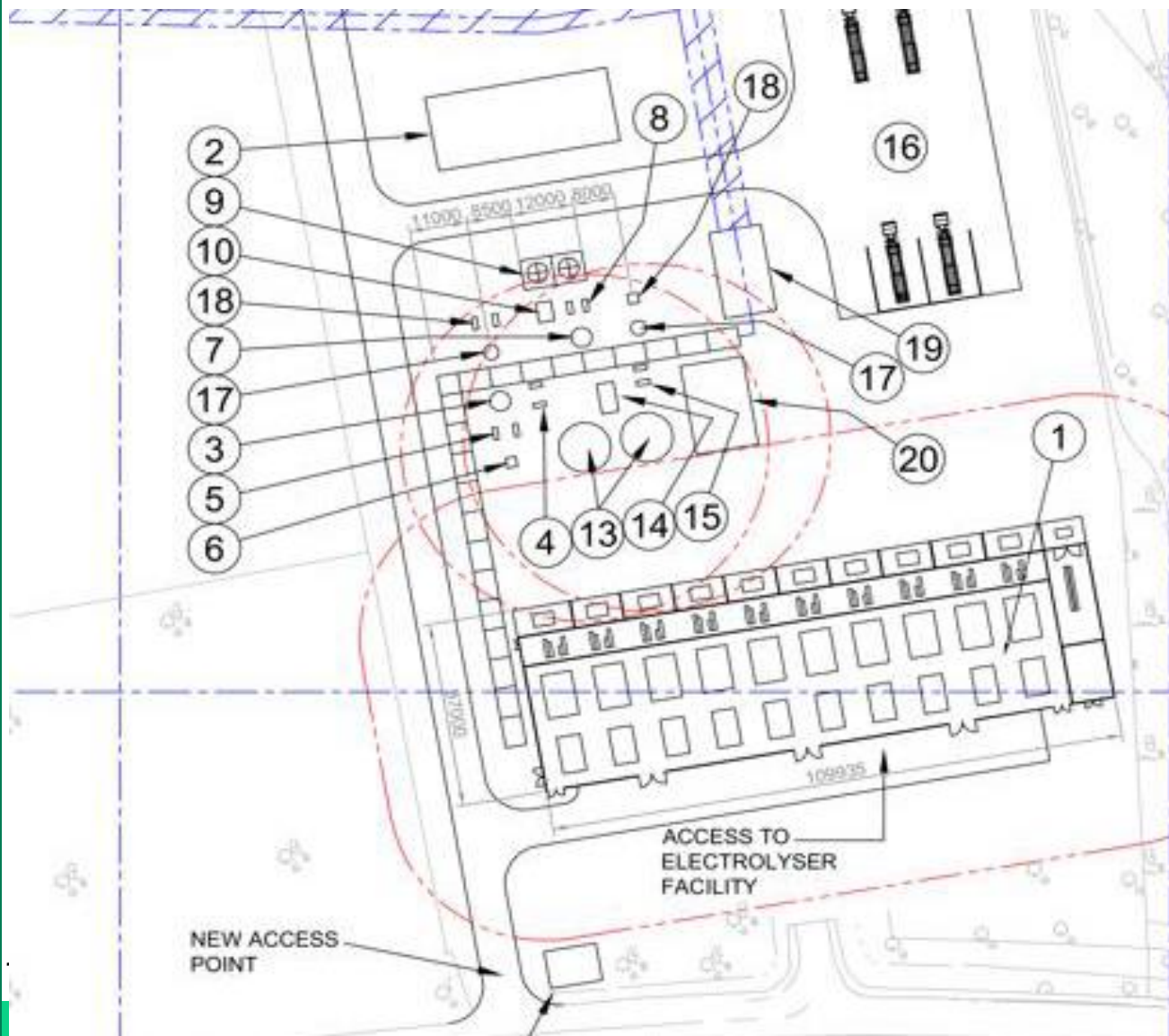


Safety and Code requirements

- This will allow buffer system for filling Tube Trailer for Transportation when industrial demand reduces. (Container as per ISO 1496-3)
- Blast area need to be carefully considered while doing layout . Depends upon capacity of storage tanks. For 2 Ton container 10 meter from building and 1 meter between vessels.
- Design code for vessel at 344 Kg per sq meter ASME Sec VIII Div2
- Design code for Cryogenic services API620 , Double Wall Construction
- Piping Design as per ASME B31.3 and B 31.12
- Material of construction depends upon Temperature and Pressure considerations



Typical Layout




ITEM LIST		
ITEM No.	EQUIPMENT DESCRIPTION	INDICATIVE SIZE
1	ELECTROLYSER HALL	
2	ELECTRICAL & CONTROL BUILDING	
3	DEMIN WATER STORAGE TANK	
4	DEMIN WATER PUMP - SUPPLY	
5	DEMIN WATER PUMP - DISCHARGE	
6	DEMIN POLISHING PLANT	
7	COOLING WATER STORAGE TANK	
8	COOLING WATER PUMP	
9	COOLING WATER SYSTEM	
10	COOLING WATER HEAT EXCHANGER	
11	NITROGEN STORAGE TANK	
12	NITROGEN COMPRESSOR	
13	HYDROGEN STORAGE TANK	
14	HYDROGEN COMPRESSOR	
15	HYDROGEN REFUELING PUMPS	
16	TUBE TRAILER REFUELING	
17	LYE MIXING TANK	
18	LYE PUMPS	
19	PIGGING TRAP/LAUNCHER ASSEMBLY	
20	DEMIN WATER PRODUCTION PLANT	

Green Hydrogen Key Parameter – 100 MW

Capital Cost	12 crore per MW	100 MW will cost about 1200 Crore
Electrical Capacity	100 MW \pm 10	Availability Greater than 85%
Hydrogen Output	2000 Kg per hour	Variation due to efficiencies of various electrolysers
Balance of Plant	10 MW	Compression, Demin water production, Site power, Electrolyze cooling, electrical efficiency losses and auxiliary power
Electrolyzer Efficiency	53KWH/ kg	Varies between Licensor
DM Water Requirement	10 Liter per kg of Hydrogen	20 cubic meter per hour
Cooling Requirement	System with an ability to remove 25MW \pm 5MW from electrolyse	
Plant Life	25 years	
Turn down ration	Range of 10-100% per module	

Green Hydrogen Key Parameter – 100 MW

Cost of Green Power	Rs 3.50 per kWh	Using power banking with grid option
Selling price of Green Hydrogen	Rs 400.0 per kg minimum	For payback period of 6 years
Grey Hydrogen Carbon Credits	1 MT equal to 10 MT of CO2	Carbon credit \$ 40 per MT of CO2
Carbon Credit per kg of Hydrogen	Rs 35	
Hydrogen produced from Methane	Rs 250	4 Kgs of Methane per Kg of Hydrogen
Government subsidy being proposed	Rs 50 per Kg of Hydrogen	
Cost of 1 MW of solar plant	Rs 350 crore per MW	Interstate transmission pf power through national grid is free , only charges levied is transmiss

Key Take Aways

- Every Ton of Green Hydrogen produced, 10 MT of CO2 credits
- Additional Taxes will be levied if we do not shift to Zero Carbon Footprint for our production plant.
- Cost of Green Hydrogen will come down as Electrolyzer cost comes down due to domestic production of Electrolyzer
- India is a hub of solar green energy due to lot of Sunlight available in various parts of country
- Liquid Hydrogen may be shipped in cryogenic containers as liquification temp of Hydrogen is minus 252 Deg Celsius. Huge export potential. Facilities at port for handling Liquid Hydrogen need to be set up
- No dependence on fluctuating gas prices
- Need to do electrical Grid assessment(400Kv) and water supply assessment