YGL 2022 Emerging Opportunities
Investment Decision Analysis: Early-Mover Hydrogen Hub

Case Study Hypothetical:

Context

A growing number of nations have committed to transition their economies to net-zero emissions by around mid-century. there is increasing commitment to three key supply-side strategies in the energy and industrial sectors:

1) Clean electricity deployment
2) Clean fuels including hydrogen and biofuels
3) CO_2 capture and storage

Central among almost all national low carbon strategies is a clean hydrogen economy with scenarios projecting from 500 million to over 1,000 million tonnes per year.

As a result, most major economies now have a national green hydrogen strategy and some countries are planning a reliance on major seaborne traded supplies.

Task

Each team has the task of developing a preliminary investment case for a standalone 1 million tonne/year clean hydrogen hub in your assigned country (one of U.S., Saudi Arabia, India, and Australia).

There are two configurations under consideration:

A. Large scale electrolyzers powered from the grid which is being decarbonized over time; and
B. Large scale electrolyzers powered from a dedicated renewable energy hub comprising wind and solar PV capacity.

Each country has different has a different combination of resource quality, capital costs, feedstock/operating costs, price on emissions (see Excel data sheet). Each country also has a set a different offtake price for early mover clean hydrogen production and a different weighted average cost of capital (WACC).

You have been provided with a discounted cashflow (Excel) model which will allow you to make the following decisions: Clean Hydrogen-Hub Country Data & DCF REV

1) Is the project likely to proceed at the proposed clean hydrogen off-take price?
2) What alternative price would be required for the project to be viable meet your required WACC?
3) In order for you to proceed with the investment, which of the following government concessions would be preferable?
    a. Government Capital Grant of 1/3 of total investment
    b. Loan Guarantee which reduced the WACC by 2%
    c. Increase in the offtake price by $2/kg
4) **Optional challenge if time:** Several countries have set a target of <$2/kg of green hydrogen by 2030, which is when your facility will come online. What combination of capital cost reductions, electricity prices and/or efficiency improvements would be needed to hit that target?

GRID CONNECTED CLEAN HYDROGEN HUB				
HUB CAPACITY	**1,000,000**	**Tonnes per year Hydrogen**		
	140,000,000	**GJ per year Hydrogen**		
For reference				
For use in discounted cashflow				
COUNTRY	**UNITED STATES**	**SAUDI ARABIA**	**INDIA**	**AUSTRALIA**
	Texas	National	Rajasthan	Western Australia
Capital Cost (2026 USD REF)				
Electrolyzer ($'000/MW in)	$ 1,100	$ 1,100	$ 750	$ 1,200
Operating Cost (2026 USD REF)				
Electrolyzer				
Fixed O&M cost ($'000/MW)	$ 55	$ 52	$ 44	$ 60
Variable O&M Cost ($/GJ H_2)	$ 0.10	$ 0.10	$ 0.08	$ 0.12
CO2 Intensity of Country Electricty Grid				
Starting CO_2 Intensity in 2022 (tonnes CO_2/MWh)	0.32	0.36	0.72	0.60
% decline in Grid CO_2 intensity per year	10%	5%	5%	10%
Facility Sizing				
Electrolyzer Capacity Factor	90%	90%	82%	88%
Electrolyzer Conversion Efficiency	70%	69%	67%	70%
Electricity Consumption (MWh/tonne H_2)	50	50	50	50
Electolyzer Capacity (GW in)	9.06	9.19	10.39	9.27
Project Cost Parameters				
Electrolyzer Rated Capacity (tonnes H_2/year)	1,110,000	1,110,000	1,220,000	1,140,000
Capital Cost of Electrolyzer Facilities ($'000)	$ 10,000,000	$ 10,100,000	$ 7,800,000	$ 11,100,000
Fixed O&M Costs of Electrolyzer Facilities ($'000/year)	$ 500,000	$ 480,000	$ 460,000	$ 560,000
Average Electricty Cost ($/MWh)	$ 40	$ 30	$ 50	$ 50
Variable O&M Costs of Electrolyzer Facilities ($'000/tonne H_2)	$ 0.014	$ 0.014	$ 0.011	$ 0.017
Feasibility, Permitting & Financing Costs (% of Total Facilities Capital Cost)	4%	4%	3%	4%
Assumptions (common across all Countries)				
Assume Feasibility and Financing costs spent evenly through years	2023 - 2025			
Assume Construction Capital Spent evenly through years	2026 - 2029			
First Production in 2030, followed by ramp up as shown	Year 1	80%		
	Year 2	94%		
	Year 3	100%		
General Economic Data				
Weighted Average Cost of Capital (Real)	6.2%	5.8%	8.5%	6.5%
'Clean' Hydrogen Price (Government price for early demonstrations in $/kg)	$ 2.50	$ 2.50	$ 3.50	$ 3.20
CO_2 Price ($/tonne Real)	$ 42	$ 30	$ 15	$ 42
Project Economic Life (years)	25	25	25	25

DEDICATED RENEWABLE CONNECTED CLEAN HYDROGEN HUB				
HUB CAPACITY	**1,000,000**	**Tonnes per year Hydrogen**		
	140,000,000	**GJ per year Hydrogen**		
For reference				
For use in discounted cashflow				
COUNTRY	**UNITED STATES**	**SAUDI ARABIA**	**INDIA**	**AUSTRALIA**
	Texas	National	Rajasthan	Western Australia
Capital Cost (2026 USD REF)				
Electrolyzer ($'000/MW in)	$ 1,200	$ 1,000	$ 700	$ 1,350
Wind Farm ($'000/MW installed)	$ 1,100	$ 1,100	$ 1,000	$ 1,200
Solar Farm ($'000/MW installed)	$ 800	$ 600	$ 500	$ 900
Operating Cost (2026 USD REF)				
Electrolyzer				
Fixed O&M cost ($'000/MW)	$ 55	$ 50	$ 36	$ 60
Variable O&M Cost ($/GJ H_2)	$ 0.10	$ 0.10	$ 0.08	$ 0.12
Wind				
Fixed O&M cost ($'000/MW)	$ 43	$ 36	$ 21	$ 50
Variable O&M Cost ($'000/MWh)	$ -	$ -	$ -	$ -
Solar				
Fixed O&M cost ($'000/MW)	$ 15	$ 12	$ 7	$ 18
Variable O&M Cost ($'000/MWh)	$ -	$ -	$ -	$ -
Renewable Energy Details				
Wind Farm	42%	38%	34%	36%
Solar Farm	24%	25%	24%	25%
% Wind (Installed Capacity)	60%	20%	20%	30%
% Solar (Installed Capacity)	40%	80%	80%	70%
Facility Sizing				
Electrolyzer Capacity Factor	61%	58%	53%	56%
Electrolyzer Conversion Efficiency	70%	69%	67%	70%
Electricity Consumption (MWh/tonne H_2)	50	50	50	50
Electolyzer Capacity (GW in)	13.43	14.27	15.97	14.53
Wind Farm Capacity (GW)	19.2	20.7	23.8	20.8
Solar Farm Capacity (GW)	19.2	20.7	23.8	20.8
Project Cost Parameters				
Electrolyzer Rated Capacity (tonnes H_2/year)	1,650,000	1,730,000	1,870,000	1,780,000
Capital Cost of Power Generation Facilities ($'000)	$ 36,400,000	$ 35,200,000	$ 35,700,000	$ 43,600,000
Capital Cost of Electrolyzer Facilities ($'000)	$ 16,100,000	$ 14,300,000	$ 11,200,000	$ 19,600,000
Fixed O&M Costs of Power Generation Facilities ($'000/year)	$ 1,110,000	$ 990,000	$ 670,000	$ 1,410,000
Fixed O&M Costs of Electrolyzer Facilities ($'000/year)	$ 740,000	$ 710,000	$ 570,000	$ 870,000
Variable O&M Costs of Power Generation Facilities ($'000/tonne H_2)	$ -	$ -	$ -	$ -
Variable O&M Costs of Electrolyzer Facilities ($'000/tonne H_2)	$ 0.014	$ 0.014	$ 0.011	$ 0.017
Feasibility, Permitting & Financing Costs (% of Total Facilities Capital Cost)	4%	3%	2%	4%
Assumptions (common across all Countries)				
Assume Feasibility and Financing costs spent evenly through years	2023 - 2025			
Assume Construction Capital Spent evenly through years	2026 - 2029			
First Production in 2030, followed by ramp up as shown	Year 1	80%		
	Year 2	94%		
	Year 3	100%		
General Economic Data				
Weighted Average Cost of Capital (Real)	6.2%	5.8%	8.5%	6.5%
Green Hydrogen Price (Government price for early demonstrations in $/kg)	$ 4.50	$ 4.50	$ 5.50	$ 5.20
CO_2 Price ($/tonne Real)	$ 42	$ 30	$ 12	$ 42
Project Economic Life (years)	25	25	25	25