



# REPORT ON GREEN HYDROGEN

BRIDGING THE GREEN GAP - INVESTIGATION INTO PROJECT ECONOMICS OF GREEN H<sub>2</sub>

APRIL 2025



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# EXECUTIVE SUMMARY

## Import substitution: the untapped driver of India's H<sub>2</sub> demand from traditional sources

India's incumbent H<sub>2</sub> demand, embedded within the substantial importation of natural gas for fertiliser and refinery applications, constitutes a significant ~9 mn tonnes, predominantly as grey H<sub>2</sub>. Since these end users are near saturation (and expected to grow by only ~3% per annum hereon), H<sub>2</sub> demand in India has grown slowly at ~5-6% per annum. Hence, *bulk of the demand from traditional sectors would be for substitution of natural gas imports* – which is one of the aims of the NGHM.

## Green light for growth: new H<sub>2</sub> uses hinge on reducing both carbon and costs

Emerging H<sub>2</sub> applications in transport, steel production, and piped gas blending remain underdeveloped due to current cost premia relative to incumbent solutions and the comparable emissions profile of grey H<sub>2</sub> production. Green H<sub>2</sub> presents a transformative potential, with various pilot projects exploring these applications. While demand from these nascent sectors is contingent on significant cost reductions, *an estimated incremental demand of ~2-5 mn tonnes could materialise by 2030*

## SIGHT Lines: growing interest through incentives, with more to come

To achieve stated objectives, the Union initiated the Rs. 175 bn SIGHT scheme, offering incentives across the green hydrogen value chain, from electrolyser manufacturing to green molecule synthesis. Component 1 (electrolyser manufacturing) is fully subscribed, while Component 2 (green molecule synthesis) has achieved 40% allocation. Scheme interest is escalating, evidenced by a 33% average reduction in incentive demands for green molecule manufacturing between tranches and sustained interest from major players across all categories. Subsequent modes of SIGHT also close a critical chink by tying up demand and are expected see fair traction.

## High energy costs and primitive electrolyser technology create the green gap

SIGHT incentives for green molecule production are projected to reduce green H<sub>2</sub> costs by approximately Rs. 15/kg over the project lifecycle. However, this subsidy is insufficient to bridge the current cost differential, with green H<sub>2</sub> priced at ~Rs. 300/kg compared to grey H<sub>2</sub> at ~Rs. 150/kg. Achieving project viability necessitates a confluence of factors, including substantial reductions in power costs, enhanced electrolyser scale and efficiency, operational expenditure optimisation, and supplementary revenue generation from heat and O<sub>2</sub> byproducts.

## Filling the green gap: large players with integrated renewable capacity and tied-up use cases will get the most breathing space on viability

Key success factors for green H<sub>2</sub> projects include substantial operational scale, access to captive renewable energy sources with storage in favorable regions (potentially yielding savings up to Rs. 75/kg), secured demand through internal consumption or long-term HPAs, access to cost-effective, high-efficiency electrolysers (benefiting from intra-group access to electrolyser manufacturing subsidies), adequate storage and transport infrastructure (proximity to demand centers, green H<sub>2</sub> hubs, or East Coast for exports), and high average incentive capture (ideally exceeding Rs. 25/kg). Consequently, vertically integrated players with access to low-cost financing are best positioned for success, while smaller, pure-play operators lacking offtake agreements face significant viability risks.

# 01 THE GAS IS GREEN, BUT ARE ITS ECONOMICS?



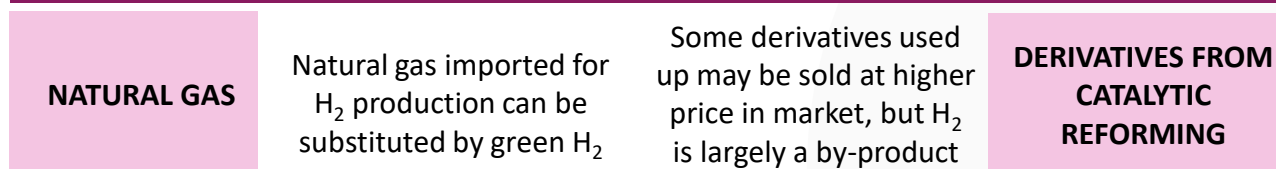
# IMPORT SUBSTITUTION TO DRIVE GREEN H<sub>2</sub> DEMAND FROM TRADITIONAL SOURCES

## INDIAN H<sub>2</sub> DEMAND IN FY25 (mn tonnes)

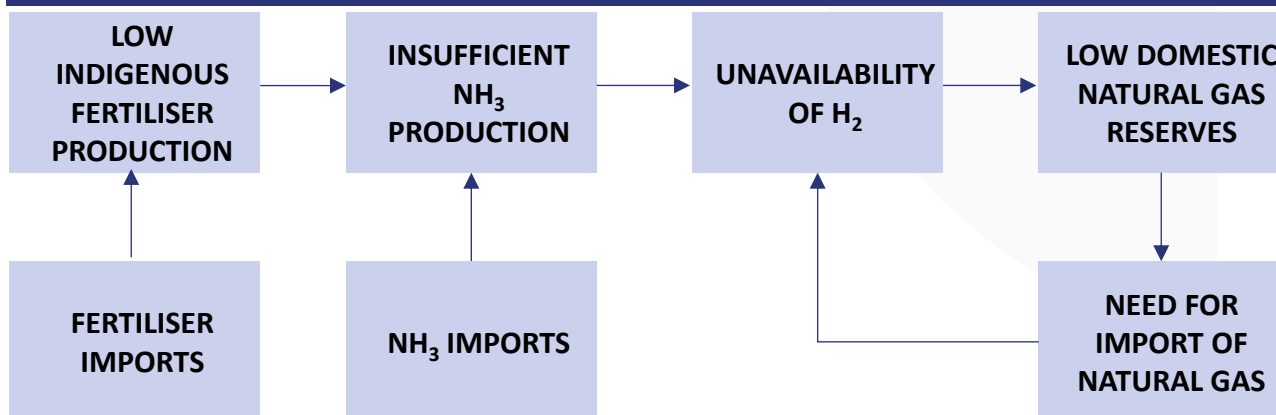


- India's H<sub>2</sub> demand (entirely fulfilled by grey H<sub>2</sub>) has exhibited a moderate growth of 5-6% per annum in the past few years
- Much of H<sub>2</sub> used in traditional consumers is imported directly or indirectly via natural gas or ammonia. This means latent demand for H<sub>2</sub> is much higher than what is produced and that import substitution could drive green H<sub>2</sub> demand

### SUBSTITUTION IMPACT IS MORE SUBDUED IN REFINERIES AS HYDROGEN IS A NATURAL BYPRODUCT IN SOME PROCESSES

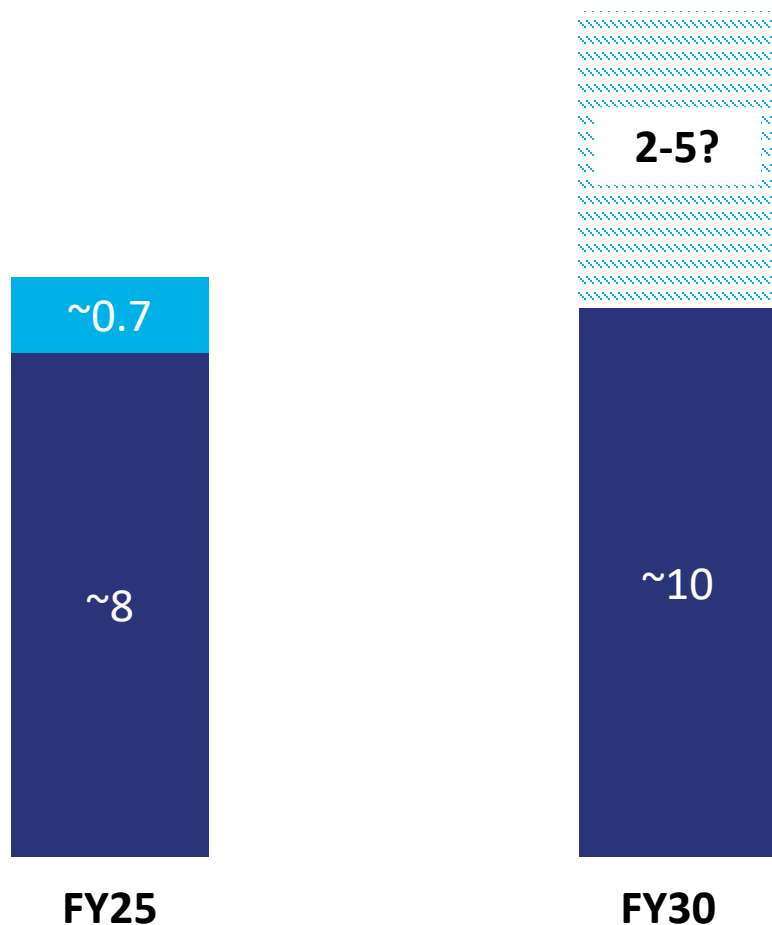


### IMPORTS AT MULTIPLE LEVELS IN FERTILISER INDUSTRY CAN BE PREVENTED IF GREEN H<sub>2</sub> IS PRODUCED INDIGENOUSLY



# DECARBONISATION IMPERATIVE CRITICAL TO GREEN H<sub>2</sub> IN NEW USES

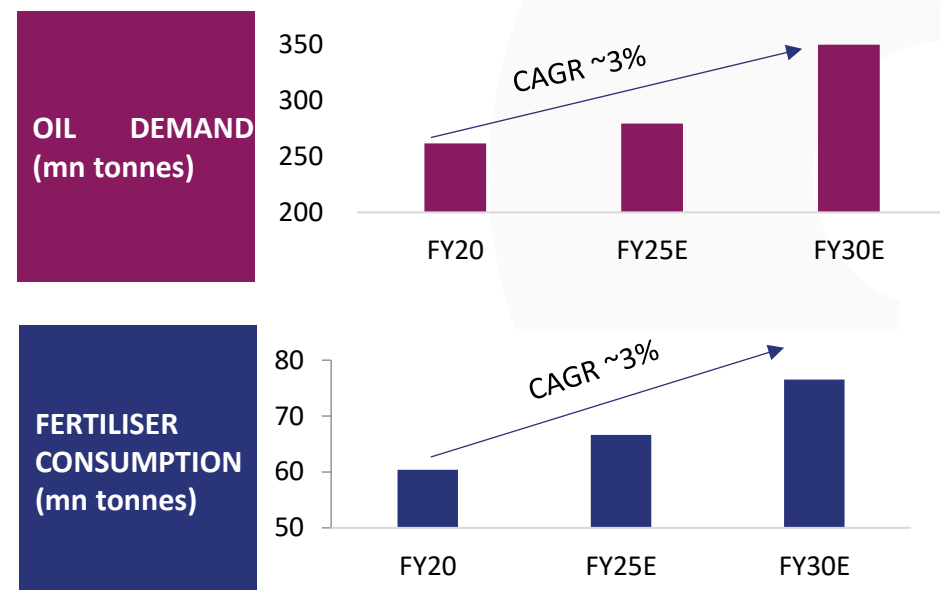
## INDIAN H<sub>2</sub> DEMAND (mn tonnes)



Consumption in other uses is expected to grow faster, and the fate of growth in these depends on growth of green as a theme, and green H<sub>2</sub> in particular

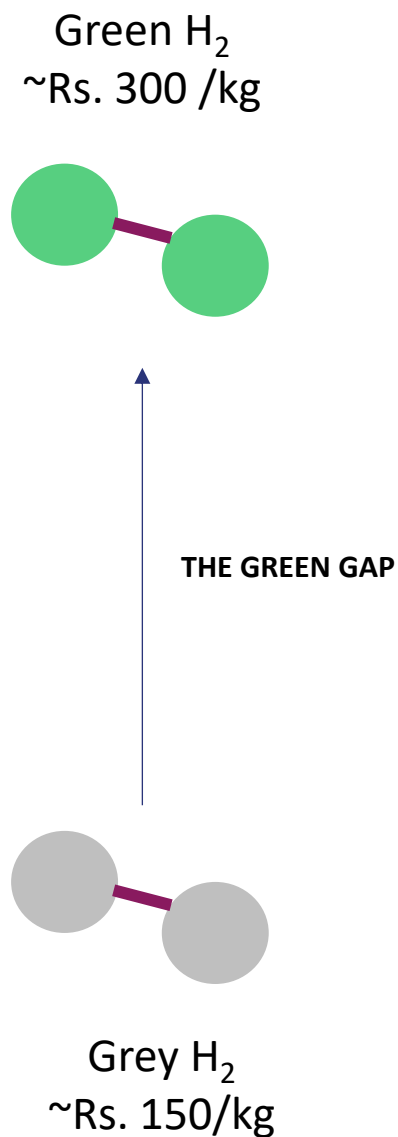
Consumption of traditional users is expected to grow slowly, substitution of imported H<sub>2</sub> can be a driver.

Use Case	Remarks
Steel	Decarbonisation, substitute for coke as reducing agent
Transport	Decarbonisation, used in heavy duty applications where batteries are impractical
Blending	Decarbonisation, to reduce emissions associated with natural gas
Glass	Significant growth expected from glass used in solar modules



Therefore, India has ample demand to absorb the 5 mn tonnes per annum of Green H<sub>2</sub> capacity envisaged by the NGHM

# HIGH COST PREVENTS EASY ADOPTION OF GREEN H<sub>2</sub>



## LCOH OF GREEN H<sub>2</sub> (Rs./kgH<sub>2</sub>)

$$LCOH = \eta \left\{ \left( \frac{(i * (1 + i)^n}{(1 + i)^n - 1} + OPEX \right) * \frac{CAPEX}{n * U * 24 * 365} + E \right\}$$

WACC

Annual OPEX as % of CAPEX

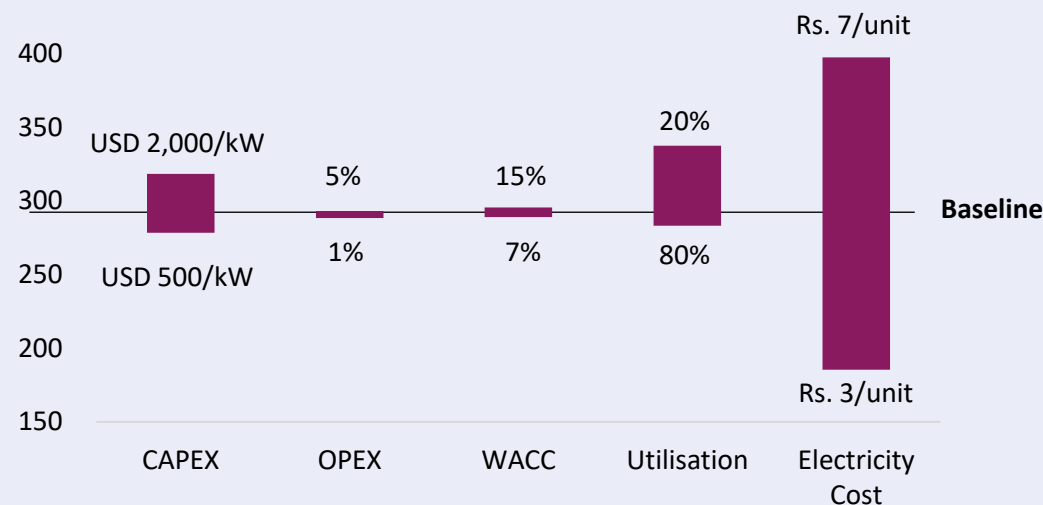
Capex per kW

Electricity Cost

Conversion efficiency of Electrolyser

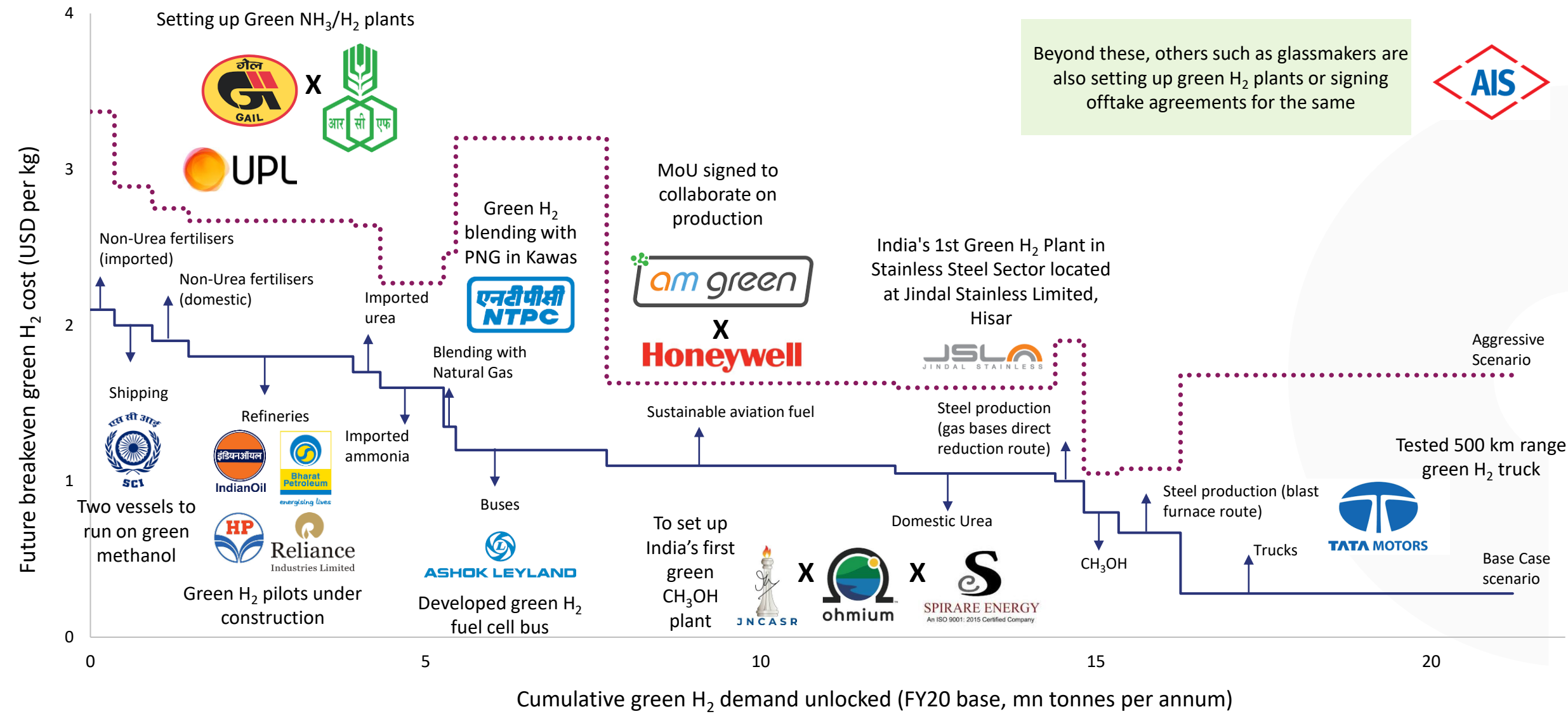
Asset Life

Utilisation Factor



The system shows high sensitivity to power and capex costs, hence minimizing these will be critical to bridge THE GREEN GAP

# GREEN H<sub>2</sub> COST CUTS CAN HELP USAGE IN MORE APPLICATIONS BREAK EVEN





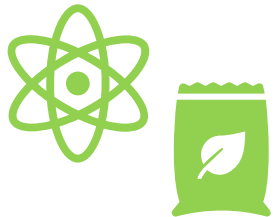
# FORE'SIGHT' ON OPPORTUNITY OR 'OVERSIGHT' ON VIABILITY?



**TOTAL OUTLAY**  
Rs. 175 bn



**ELECTROLYSER**  
Rs. 44.4 bn  
Fully allocated



**GREEN H<sub>2</sub> & DERIVATIVES**  
Rs. 130.5 bn  
40% allocated

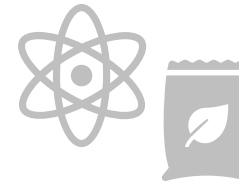
**5 MN TONNES CAPACITY  
BY 2030**

**INVESTMENTS**

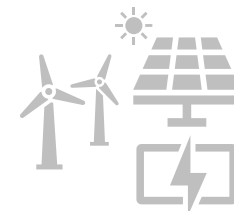
**Rs. 8-10  
trn**



**ELECTROLYSER MANUFACTURING**  
~Rs. 1.5 trn



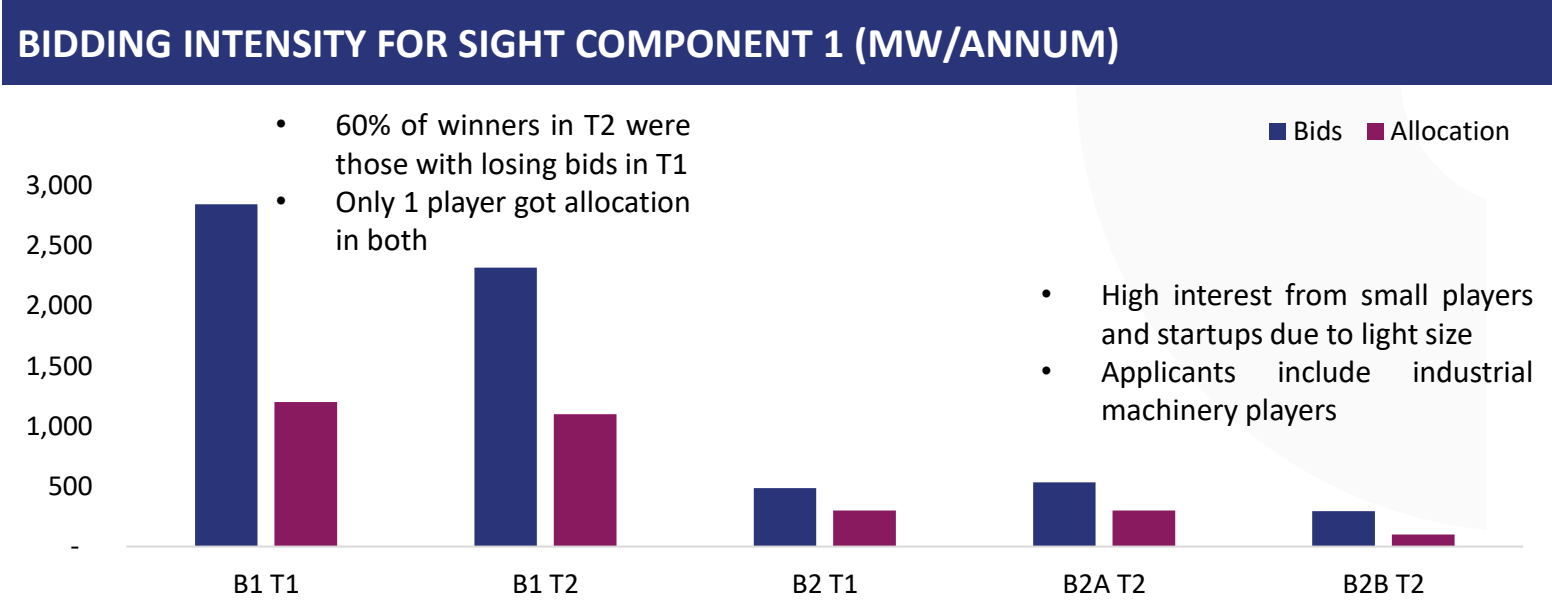
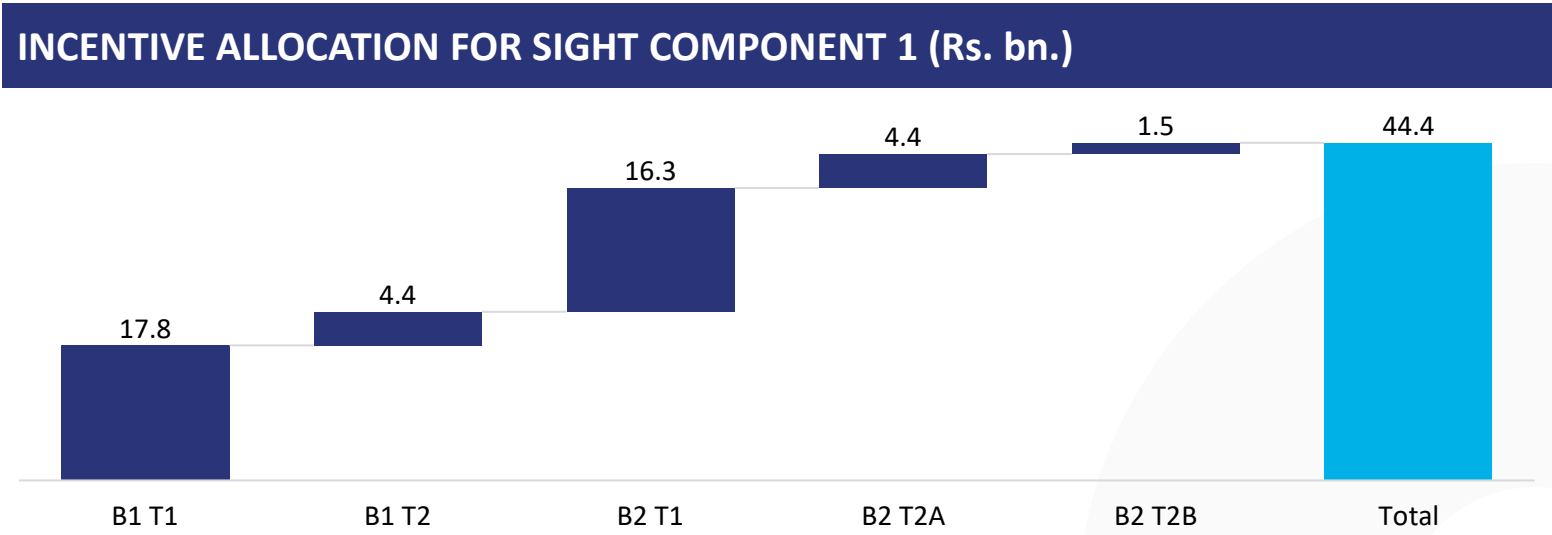
**GREEN H<sub>2</sub> & DERIVATIVES**  
~Rs. 3 trn



**ASSOCIATED RENEWABLES**  
~Rs. 4.5 trn

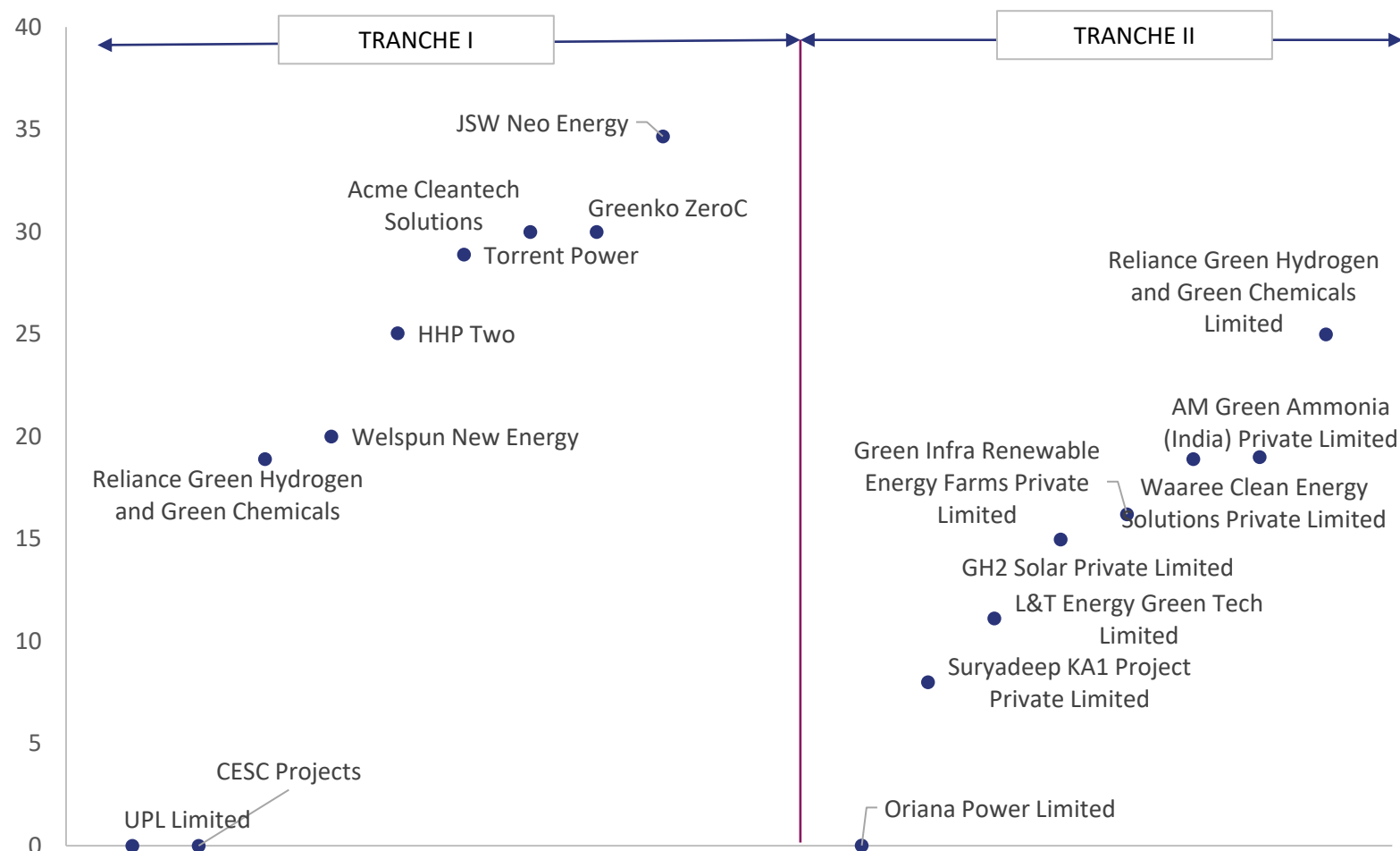
# ELECTROLYSER MANUFACTURING COMPONENT SEES COMPLETE ALLOCATION

Scheme	Component 1
End Product	Electrolysers
Basis of Bid	Highest index based on specific energy consumption and local value addition. Some preference to small players
Outlay (Rs. bn.)	44.4 (Fully allocated)
Implementation Agency	SECI
Incentive (Fixed)	I = Rs. 4,400/kW in Year 1, progressively decreasing till Year 5
Other Details	<p>First Tranche of 1,500 MW:</p> <ul style="list-style-type: none"> <li>• Bucket 1: 1,200 MW (any stack)</li> <li>• Bucket 2: 300 MW (indigenous stack technology)</li> </ul> <p>Second Tranche of 1,500 MW:</p> <ul style="list-style-type: none"> <li>• Bucket 1: 1,100 MW (any stack)</li> <li>• Bucket 2A: 300 MW (indigenous stack technology)</li> <li>• Bucket 2B: 100 MW (indigenous stack technology – smaller units)</li> </ul>



# BIDDING INTENSITY INCREASES FOR GREEN MOLECULE COMPONENT

## AVERAGE INCENTIVE FOR SIGHT COMPONENT 2 MODE 1 BUCKET 1 (Rs./kg)

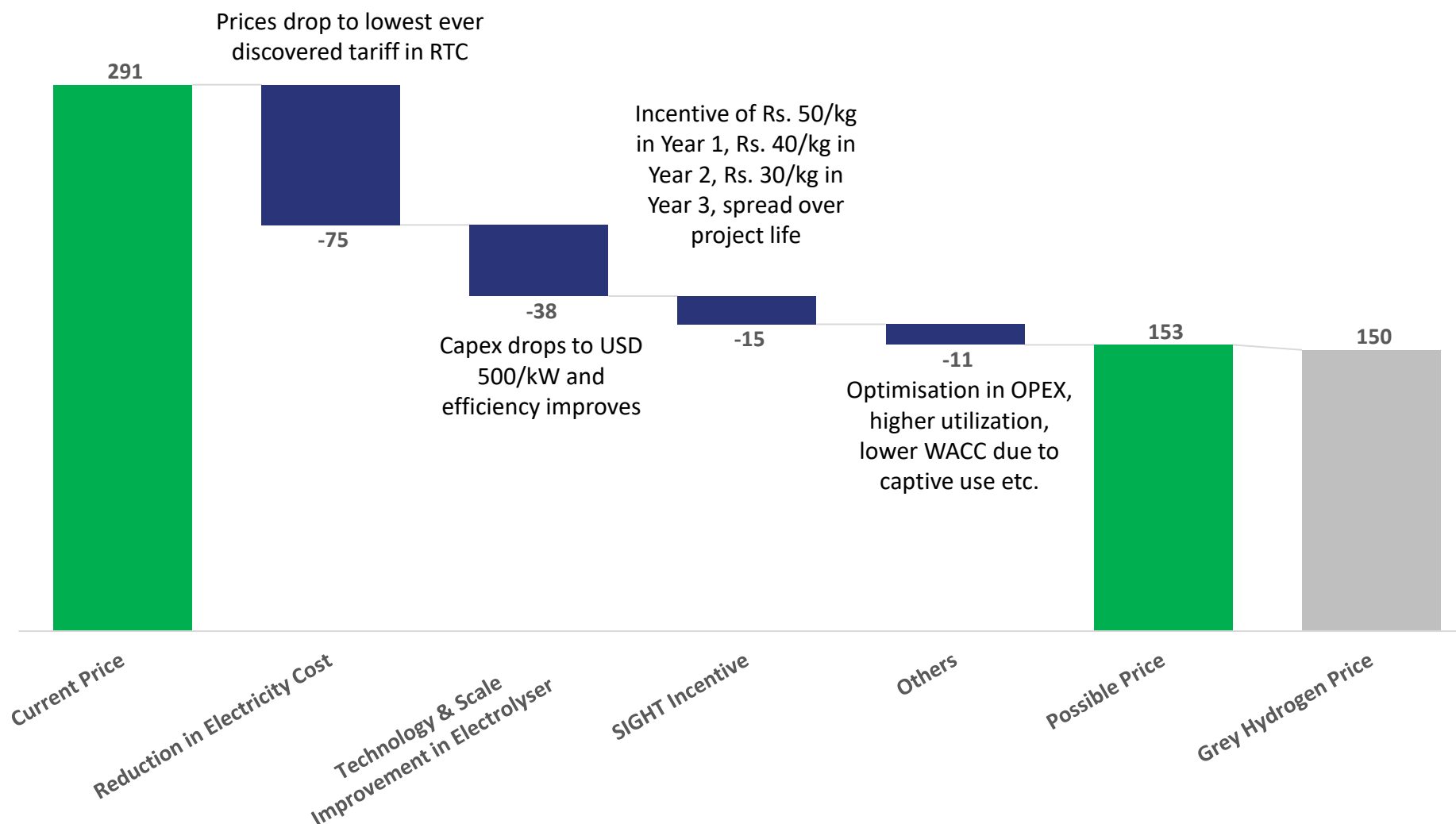


Scheme	Component 2 Mode 1
End Product	Green Hydrogen or its derivatives
Basis of Bid	Least average incentive demanded over 3-year period
Outlay (Rs. bn.)	130.5 across modes
Implementation Agency	SECI
Incentive (Upper Caps)	I = Rs. 50/kg in Year 1, Rs. 40/kg in Year 2, and Rs. 30/kg in Year 3
Other Details	Each Tranche of 450 ktpa: <ul style="list-style-type: none"> <li>• Bucket 1: 410 ktpa (technology agnostic)</li> <li>• Bucket 2: 40 ktpa (biomass pathway)</li> </ul>

- Both tranches of Bucket-1 saw bids above notified, with bidding intensity increasing, reflecting high interest
- Bucket 1 has seen incentive demanded moving down 33% between the tranches, with lesser dispersion indicating better benchmarking and price discovery
- Bucket 2 saw limited traction in both tranches, though better interest was seen in Tranche 2

# BRIDGING THE GREEN GAP WILL BE A LONG-DRAWN JOURNEY FOR MOST

## POSSIBLE PATHWAY TO LOWERING PRICE OF GREEN H<sub>2</sub> (Rs./kg)



- Consistent reduction in electricity cost can be achieved through:
  - Having ample captive renewable capacity in lucrative sites, with storage
  - Allowing unlimited power banking
  - Waiver of open-access charges for captive RE for green H<sub>2</sub>
  - Waiver of InSTS charges in addition to ISTS charges
  - Dedicated solar parks near green H<sub>2</sub> hubs
  - Use of BSR captive plants
- Optimisation of electrolyser cost can be either through access to cheap Chinese PEM models (which needs scale) or through indigenous stack development
- Sale of by-product (O<sub>2</sub>) can generate about Rs. 10-40/kgH<sub>2</sub> which can further cushion the difference
- Exports to NE Asia could be viable from the East Coast of India given higher prices of green H<sub>2</sub> expected there

# LENDING TO BE SELECTIVE, ADHERING TO A PATCHWORK OF FACTORS

Average Project Size: 50,000 tpa of Green H<sub>2</sub>  
Investment Need: Rs. 28 bn

Other Costs: Rs. 7 bn

Electrolyser BoP: Rs. 7 bn

Electrolyser: Rs. 14 bn

*Project sizes in SIGHT range from 10,000 to 90,000 tonnes and could entail investments from Rs. 6 bn to Rs. 50 bn+ per project*

*Players with captive renewable plants in favourable locations (high solar potential, green H<sub>2</sub> hubs/export ports) and tied-up internal demand will have the most viable projects*

## The Lending Patchwork

Project DSCR & Debt Coverage Metrics

HSA & Mix of Export/Local

Stack quality, degradation & technological obsolescence risks

Parentage & Forward/Backward links in Group

Proximity to Demand Centres (preferably Green H<sub>2</sub> hubs) & presence of transport/storage

Firm PSA Agreement or Captive, Reliable RE; Optimal mix of solar, wind, storage

Access to low cost/free water

Price of locally available Grey H<sub>2</sub>

State level incentives and policy

# LARGE TWO-WAY INTEGRATED PLAYERS TO SET UP VIABLE PROJECTS

Entity	Capacity (tpa) & Tranche	Incentive (Rs./kg)	Energy Source	Demand	Electrolyser technology	Others	
Reliance Green Hydrogen and Green Chemicals Limited	90,000 (T1), 49,000 (T2)	21.1	Planned wind capacity	Mix of captive and non-captive; located in demand centres	Internal	Strong parentage: tie-ups & low-cost funding	
Acme Cleantech Solutions Private Limited	90,000 (T1)	30.0	Captive	Non-captive; Exports (projects on East Coast)	Internal	Has operational plant in Rajasthan, funding tied up for one plant	
Greenko ZeroC Private Limited	90,000 (T1)	30.0	Captive, also has tie-up with NTPC Green for Kakinada plant	Non-captive; Exports (50% offtake tied up already)	Internal (tie-up with John Cockerill)	To be operational in 2027	
L&T Energy Green Tech Limited	90,000 (T2)	11.1	None, but has expertise	Non-captive, present in demand hub	Internal	Strong parentage: tie-ups & low-cost funding	
Green Infra Renewable Energy Farms Private Limited	90,000 (T2)	16.2	Captive	Non-captive; Exports to Japan (project on East Coast)	External	Strong parentage: tie-ups & low-cost funding	
Waaree Clean Energy Solutions Private Limited	90,000 (T2)	18.9	None, but has expertise	Non-captive	Internal	Big player in solar modules and cells	
AM Green Ammonia (India) Private Limited	90,000 (T2)	19.0	None	Non-captive (near demand centres in Gujarat and East Coast)	External	Large suite of green molecules	
				Legend	Positive	Neutral	Negative

# ALL PROJECTS ARE GREEN, BUT WILL THEIR ECONOMICS BE GREEN?

Entity	Capacity (tpa) & Tranche	Incentive (Rs./kg)	Energy Source	Demand	Electrolyser technology	Others
HHP Two Private Limited	75,000 (T1)	25.0	None	Non-captive, but has some HPAs signed	Internal	Multiple projects under Construction
Welspun New Energy Limited	20,000 (T1)	20.0	Captive	Non-captive, but has MoU signed. Export planned as well	External	Mainly in NH <sub>3</sub> and CH <sub>3</sub> OH (2 mn tonnes target by 2030)
Suryadeep KA1 Project Private Limited	19,000 (T2)	8.0	None, but has expertise	Non-captive	Internal	Part of InSolare Energy
Torrent Power Limited	18,000 (T1)	28.9	Captive	Captive (CGD Blending to extent of 2.5%)	External	Fair parentage
CESC Projects Limited	10,500 (T1)	0.0	Captive	Non-captive	External	Likely to be commissioned in 2027
GH2 Solar Private Limited	10,500 (T2)	15.0	None, but has expertise	Non-captive	Internal	Provides HaaS
UPL Limited	10,000 (T1)	0.0	None	Captive (Fertiliser)	External	Fair parentage
Oriana Power Limited	10,000 (T2)	0.01	None, but has expertise	Non-captive	Internal	Moderate financial strength
JSW Neo Energy Limited	6,500 (T1)	34.7	Captive	Captive, signed 7-year supply agreement with JSW Steel	Internal	3,800 tpa capacity Karnataka; Strong parentage

**Most projects are in nascent phase with only some pilots commissioned by major players**

Legend	Positive	Neutral	Negative
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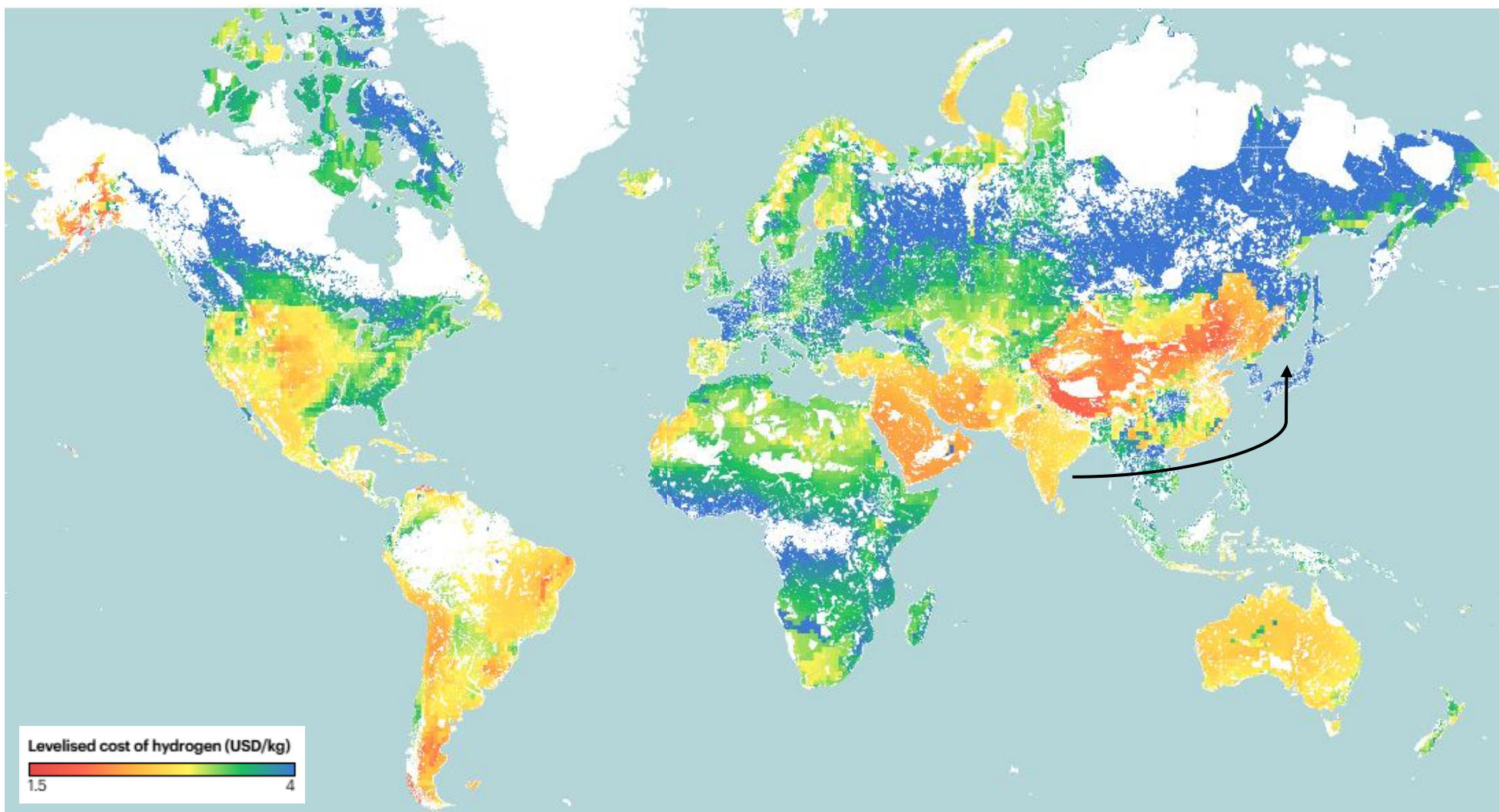


# 03 **ANNEXURE**

# ANNEXURE 1: EXPORTS TO NE ASIA FROM INDIAN EAST COAST VIABLE



## LCOH FOR GREEN HYDROGEN BY (USD/kgH<sub>2</sub>)



- LCOH in India, currently ~USD 3-3.5/kgH<sub>2</sub> remains favourably places vs. major consumers such as Japan and S. Korea, where it is >USD 4/kgH<sub>2</sub>
- IEA projects that LCOH will go up to USD 6/kgH<sub>2</sub> in Japan and S. Korea, while in India It would be between USD 2-3/kgH<sub>2</sub>
- Viability remains highest from east coast of India, and in the form of green NH<sub>3</sub> and not H<sub>2</sub> given transport-storage considerations
- An agreement for offtake of green NH<sub>3</sub> between India and Japan was signed in Aug'24

# ANNEXURE 2: GLOSSARY OF KEY TERMS

Item	Explanation
B	Bucket
bn	billion
BoP	Balance of Plant
BSR	Bharat Small Reactor
CAGR	Compounded Annual Growth Rate
capex	Capital Expenditure
DSCR	Debt Service Coverage Ratio
H <sub>2</sub>	Hydrogen
HaaS	Hydrogen as a Service
HPA	Hydrogen Purchase Agreement
IEA	International Energy Agency
InSTS	Intra-state Transmission System
ISTS	Inter State Transmission System
kg	kilogramme
kW	kilo Watt
LCOH	Levelised Cost of Hydrogen
mn	million
MNRE	Ministry of New and Renewable Energy
MW	Mega Watt
NE	North East

Item	Explanation
NGHM	National Green Hydrogen Mission
NH <sub>3</sub>	Ammonia
O <sub>2</sub>	Oxygen
Opex	Operating Expenditure
PEM	Proton Exchange Membrane
PIB	Press Information Bureau
PSA	Power Supply Agreement
RE	Renewable Energy
Rs.	Indian Rupees
RTC	Round the Clock
S. Korea	South Korea
SECI	Solar Energy Corporation of India
SIGHT	Strategic Interventions for Green Hydrogen Transition
t	tonne
T	Tranche
tpa	tonne per annum
trn	trillion
USD	United States Dollar
WACC	Weighted Average Cost of Capital



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