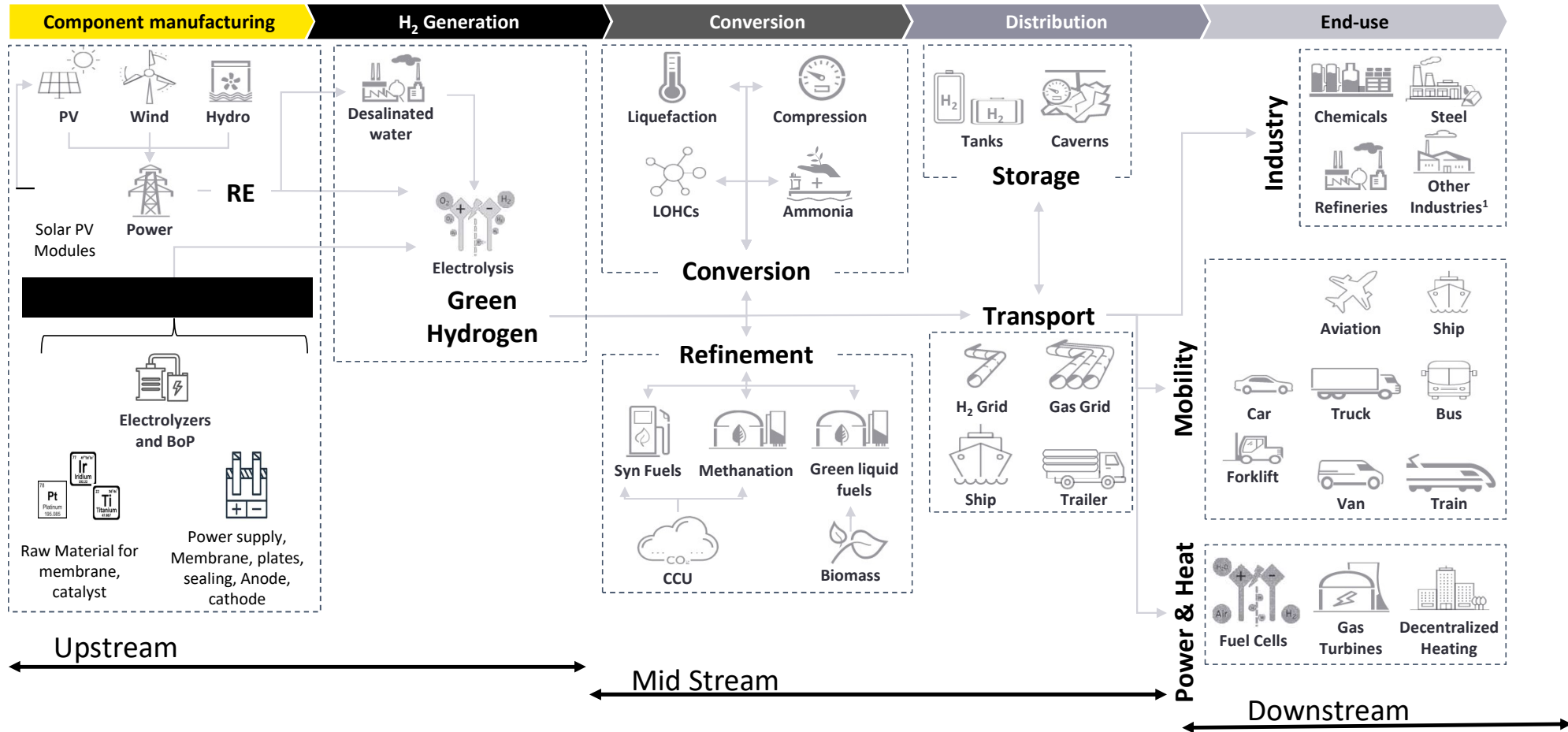
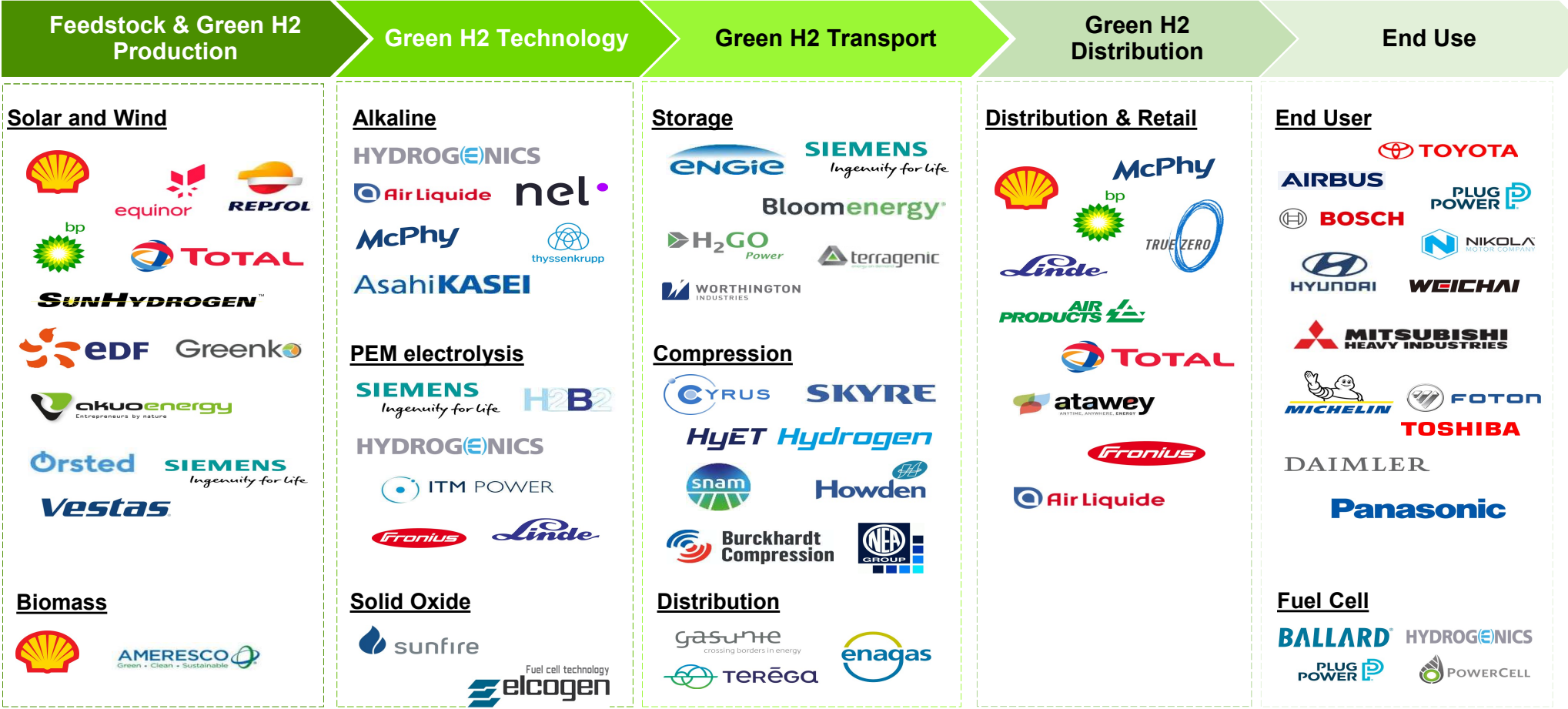


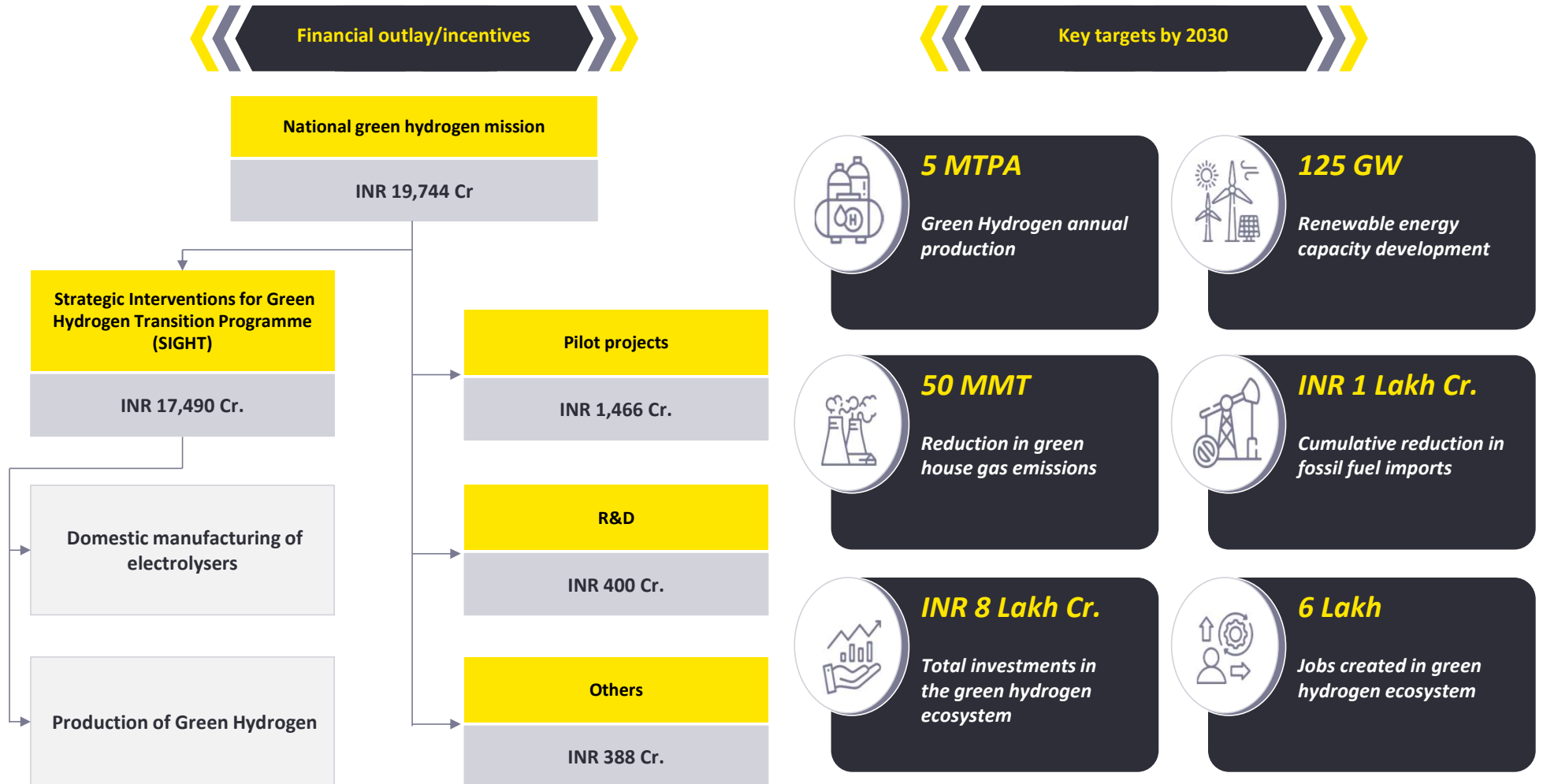
Green Hydrogen Value Chain



Companies Interested in Hydrogen Value Chain

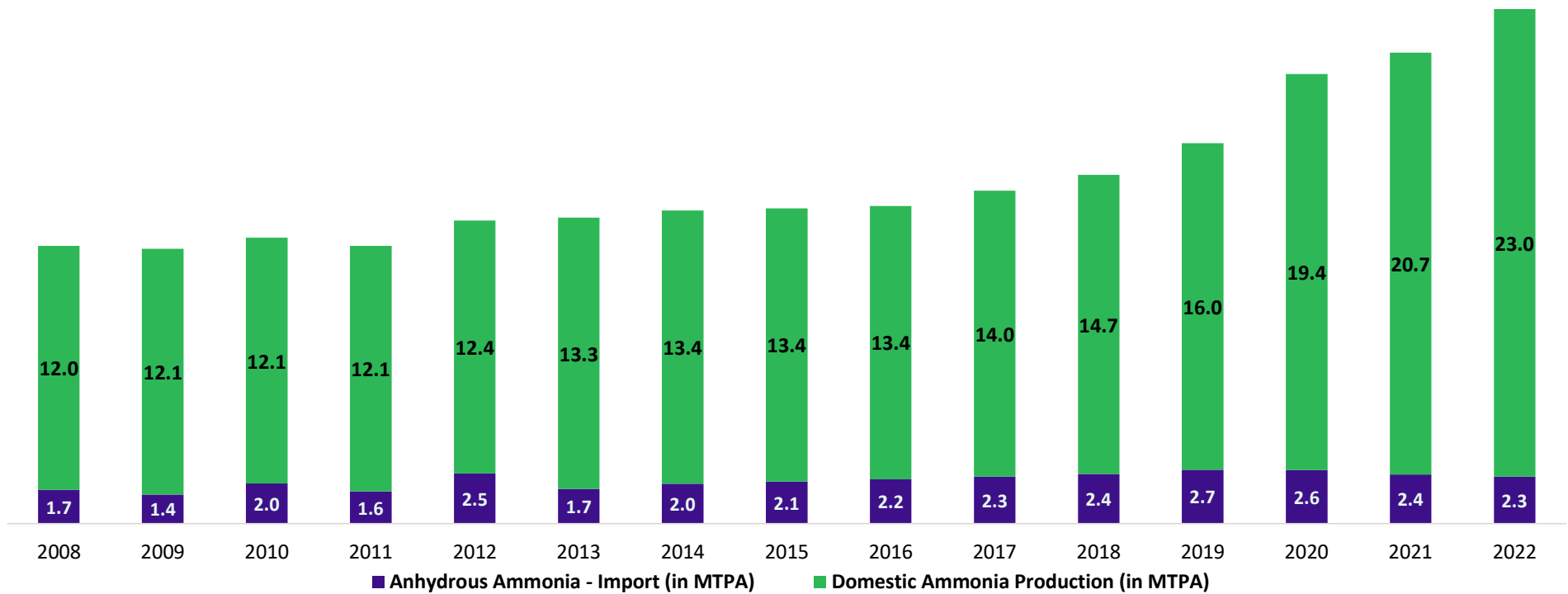


Financial Outlay and Key Targets of GOI by 2030



India is currently a net importer of ammonia; 7 – 10% (~2 MT) of the annual ammonia consumption in India is sourced from imports

Fossil based Ammonia Production versus Imports in India (in MTPA)



Source: Global Data, India Ammonia Production Capacity

(assumed the plant are operated at 90% efficiency) - Causes for Loss Time in Ammonia-Urea Plants, Fertilizer Association of India

Demand, Supply and Technology

Initial Demand & Supply assessment

- ▶ India's Ammonia demand to grow ~2.3X: **~39MT by 2030**, with fertilizer sector being the major consumer.
- ▶ ON supply side, **~10.92 MTPA** of GNH3 projects are in various stages of development/ announced/ planned across India
- ▶ Globally offtake being led by **Japanese / EU** involved in Clean/Green Fuel Ammonia projects across supply Chain
- ▶ The **market is picking up rapidly** in India – with partnerships across the value chain and **Offtake agreements** being setup at a brisk pace
- ▶ Several **H2 hubs** being envisaged & developed capable of supporting large scale production and/or utilization of H2 across India
- ▶ Potential **domestic off-takers** for G-NH3 would primarily be the **urea/fertilizer** productions plants

Initial Technology & cost assessment

- ▶ Alkaline electrolyzers are well established and have least investment cost; PEM limited by critical material availability
- ▶ The cost of GH2 & GNH3 production is highly dependent on the cost of electricity
- ▶ There are **multiple options for H2 storage**- low pressure tanks, pressurized tanks, underground tanks, line packing, cryogenic tanks, cryo-compressed, as ammonia or metal-hydride based storage; each having pros and cons
- ▶ **NH3 is compressed, liquefied and stored** at -33.34 deg C in **carbon steel tanks**; the capacity of these tanks vary from 4,550 to 50,000 tonnes per tank
- ▶ **Pipeline transport** for liquid ammonia is a preferred method of distribution/ transportation as it is cost effective and is safe/ low risk (Cost in the range of 0.02-0.05 USD/ton/km); for overseas, **fully refrigerated type 'A' tanks** are popular.

High level Business Case

- ▶ A typical green ammonia project is expected to achieve **break even in 6-8 years**, with **project IRR in the 12-14%** range based on long-term bilateral offtake agreement (base case, without any incentives or carbon pricing)
- ▶ CAPEX estimates can range from 13,000 Crores - 18,000 Crores INR depending on the **technology choice (Alkaline, PEM) and partnership agreements**, as well as the **capacity (typically 1 MTPA for green ammonia)**
- ▶ While Ammonia market is mature, green ammonia pricing is potentially evolving with **multiple price-trend scenarios possible** (including **cost-plus** and **long-term price agreements**)
- ▶ The project return is **highly sensitive** to the variation in **renewable energy cost (through PPA/captive)**, which is a major cost component in project OPEX, with direct correlation on **green ammonia price**

All kinds of players have expressed interest and made announcements in the green hydrogen ecosystem – from production of H2 to Giga-scale electrolyser manufacturing



Some Planned Developments across the Hydrogen Segment in India

\$150 Billion

Planned investment by Reliance & Adani till 2030 across renewable energy space and production of cheap hydrogen

\$15 Billion

Investment required to set up 15 GW green hydrogen electrolyser capacity in India by 2030



Invest USD 70 Bn by 2030 in gigafactories for solar PV, wind, green hydrogen electrolyzers



To develop a 4.75 GW renewable energy park including solar plant and green H2 generation unit in Leh, 60 GW RE by 2032 target



Intend to spend INR 750 Bn. to construct 4 giga factories (integrated solar PV modules, electrolyzers, fuel cells and batteries). Partnership with Denmark-based Stiesdal A/S on hydrogen electrolyzer manufacturing



JSW Future Energy plans to increase green power generation capacity to 17 GW by 2030, and has signed an agreement with Australia's Fortescue Future for green hydrogen production



Signed MoU with Norway-based HydrogenPro AS to set-up GW-scale manufacturing of alkaline water electrolyzers, to invest USD 2.5 Bn in green energy



Intend to scale up its green energy portfolio to 18 GW by 2027, investing INR 750 Bn towards renewable energy



Electrolyzer manufacturing plant of 1GW capacity, to produce solid oxide electrolyzers by 2023.



Indian Oil Corp. Ltd, Larsen and Toubro and ReNew Power have agreed to form a joint venture company to develop green hydrogen projects across the country



Renew Power will manufacture 2GW of solar cells and modules from its manufacturing facility in the state of Gujarat. It has also announced JV with IOC and L&T for green H2 business. To invest INR 300 Bn over 2 years



India's first green hydrogen electrolyser Gigafactory with initial manufacturing capacity of 500 MW/year with plans to scale to 2 GW



Spending 30,000 cr on clean energy and petrochemicals, setting up a 10-megawatt electrolyser for producing green hydrogen



HPCL to commission 370 tonne/annum capacity green Hydrogen plant by Dec 2022








Bharat Petroleum Corporation (BPCL) will soon float a tender for a 20 MW electrolyser to build the country's largest green hydrogen plant

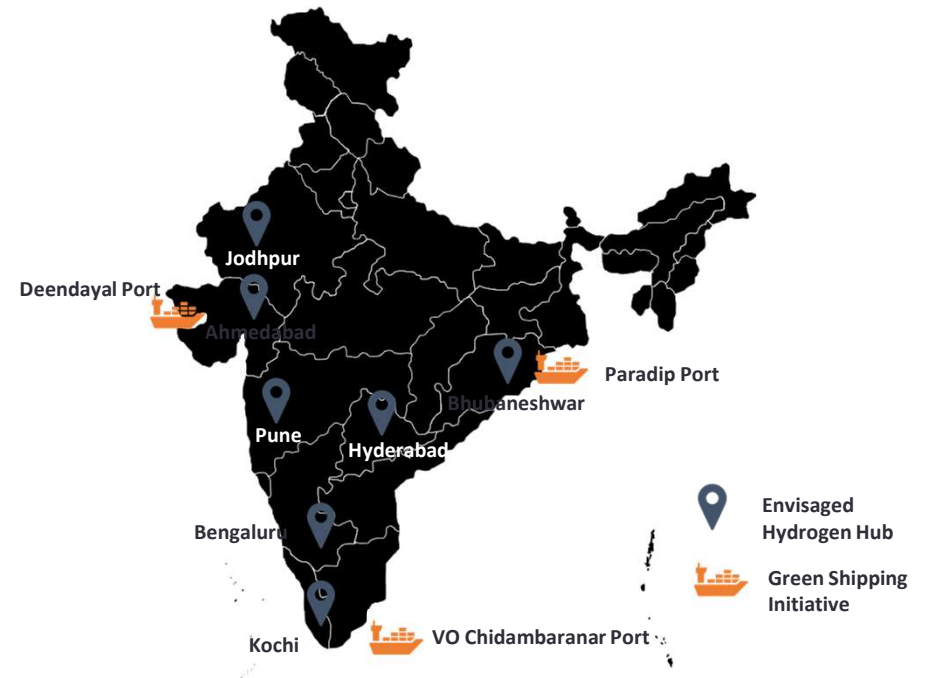


Greenko Group & Belgium's John Cockerill to set up a 2GW electrolyzer factory, with an investment of \$500 MN. along East coast

Some Key Partnerships & Offtake Agreements

	<p>Partnerships across the value chain</p> <ul style="list-style-type: none"> ○ Nexwafe, REC Solar, Caelux and SenseHawk- for solar module/technology ○ Sterling & Wilson- EPC ○ Steisdal- Alkaline electrolyzer ○ Ambri, Faradion, LithiumWerks- Energy storage ○ SkyTran- clean mobility
	<p>Offtake agreements with-</p> <ul style="list-style-type: none"> ○ Keppel- power generation ○ Uniper- power generation ○ POSCO Steel <p>Partnership with-</p> <ul style="list-style-type: none"> ○ John Cockerill (electrolyzer manufacturer) ○ ONGC (MoU)
	<ul style="list-style-type: none"> • Collaboration with France's Lhyfe Labs • Offtake agreements with <ul style="list-style-type: none"> ○ Yara (from the Oman project, Scatec is the JV partner) ○ IHI Corporation (from any project)
	<ul style="list-style-type: none"> • JV - IndianOil Corporation Limited (IOCL) + ReNew Power + L&T • Further, L&T has MoU with HydrogenPro for manufacturing electrolyzers in India
	<p>MoU for captive use with:</p> <ul style="list-style-type: none"> ○ National Fertilizers Limited (NFL) ○ Gujarat Alkalies and Chemicals Limited (GACL)

Hydrogen Hubs- Regions of GH2 production & utilisation



- Potential locations for H2 Hubs would be regions having clusters of refineries/fertilizer production plants in close vicinity.
- The three ports marked, will be developed by Ministry of Ports as H2 Hubs under Green Shipping Initiative as part of the Maritime India vision 2030.

Workstreams for Green Ammonia Production Business



Renewable energy procurement/generation

- ▶ Determining **energy mix**- Solar, solar+wind, solar+BESS
- ▶ Setting up **captive plant**/ procuring via **third party open access**
- ▶ Specifying availability
- ▶ **Grid connection** facilities



Green Hydrogen production

- ▶ **Water supply**- storage/pipeline and demineralisation
- ▶ Selection of **electrolyzer** OEM; sizing GH2 plant
- ▶ Hydrogen **storage**
- ▶ **Recovery of oxygen** (if feasible)



Ammonia Production

- ▶ Determining OEM & EPCs- for **nitrogen separation & compression** and **NH3 synthesis**
- ▶ Specifying technical limits- purity production levels etc.
- ▶ **Sizing** of NH3 plant
- ▶ Facilities for Syn compression, Synthesis loop and refrigeration



Ammonia Storage & Transport

- ▶ Sizing of **storage**; determining type
- ▶ Determining dimensions & transfer capacity of **pipeline** based on distance to port; determining if **land acquisition** is required
- ▶ Assessment of **berthing facilities** at port based on **size of vessel**; liaising with agencies



Offtake and finance Related

- ▶ Identification of **target geographies** based on market size and incentives
- ▶ **Customer longlisting and profiling** for key market segments
- ▶ Analyse competitor value proposition; develop **Own value proposition**
- ▶ Conclude key term sheet (with exclusivity clause) & offtake agreements



Land, incentives and other Risk management activities

- ▶ Identification of **site**; determination of dimension
- ▶ Submission of **incentives list** to state govt; **policy advocacy**
- ▶ Seeking **regulatory compliances** (EIA, PCB); and formulating **contracting strategies** to accommodate for the nascency/evolution of sector

THANK YOU

WELSPUN

