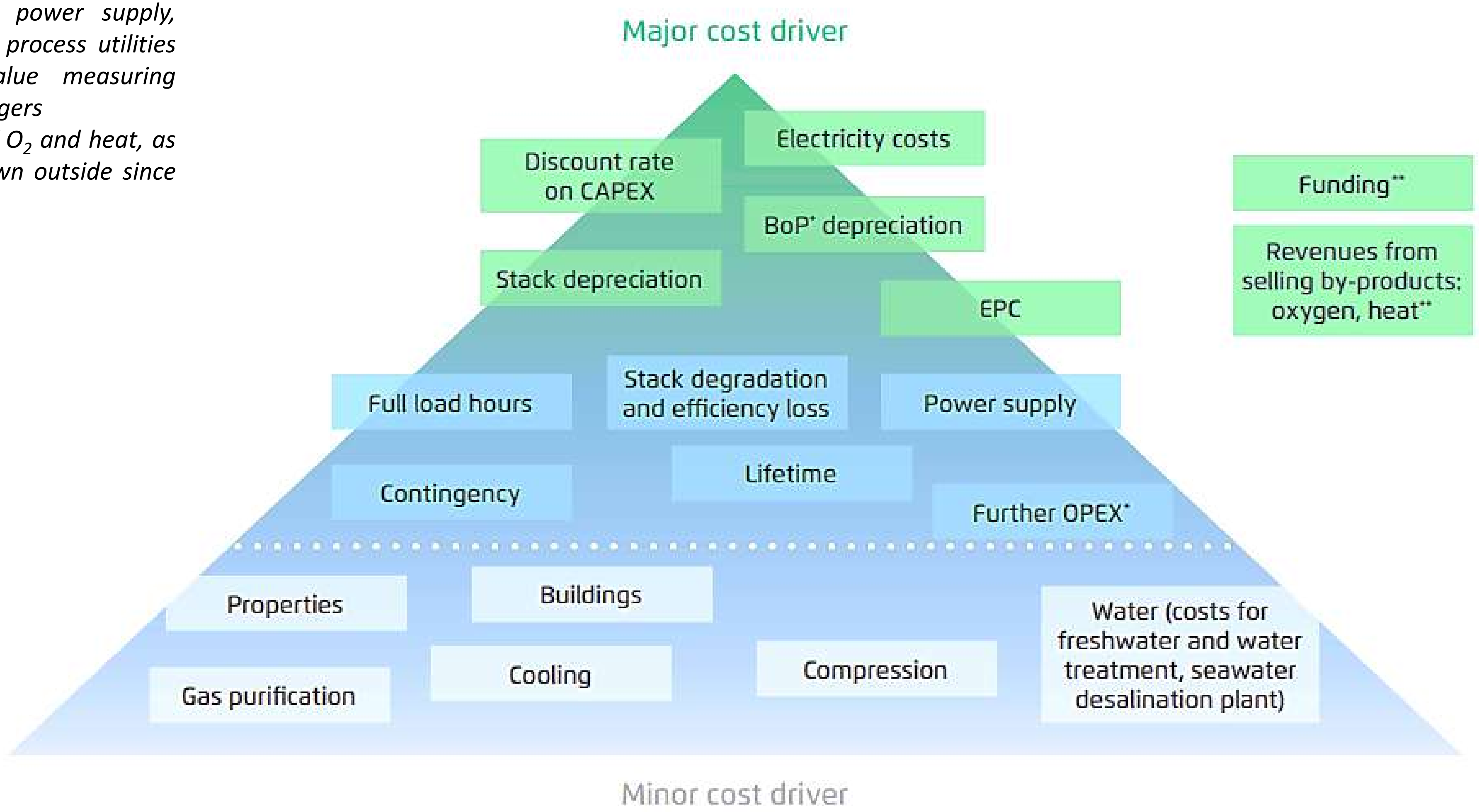
ELECTROLYSER CAPEX AND POWER EXPENSES DRIVE GREEN HYDROGEN COST

Notes:
**BoP typically includes power supply, water conditioning, and process utilities like pumps, process-value measuring devices, and heat exchangers*
***Revenues from sale of O_2 and heat, as well as funding are shown outside since they are not costs*



This typical hierarchy of costs can vary greatly based on region, utilisation of electrolysers, and scale. For instance, a 10 MW electrolyser has only 63% of specific capex of 1 MW electrolyser, which for 100 MW it further reduces to 40%

Source: Agora Energy, SBICAPS

COST VS. EFFICIENCY TRADEOFF CRITICAL IN CHOOSING ELECTROLYSER TECHNOLOGY

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	Alkaline	Proton Exchange Membrane (PEM)	
	Uses thick membranes with Ni-based electrodes. Simple system design, widely used in fertilisers, NH_3 production	*Uses thin perfluorosulfonic acid (PFSA) membranes, which necessitates use of precious metal electrodes*	
Operating Pressure	Moderate (30 bar)	High (70 bar)	Higher pressure requirement increases cost
Efficiency	Moderate (70-80%)	High (80-90%)	Higher pressure increases efficiency
Capex	USD 300-350/kW (lowest from China), USD 750-1,000 (standard)	USD 600-1,250/kW	Installation/indirect costs are typically equal to uninstalled system costs (total is ~2x)
Technology readiness	Matured and Commercialised. 2/3 of global capacity	Young and Commercialised. 1/5 of global capacity	Remaining capacity is from marginal SOEC/AEM technology
Life	60,000 hours	80,000 hours	Post life, stack replacement, which costs 60-80% of upfront capex, is needed

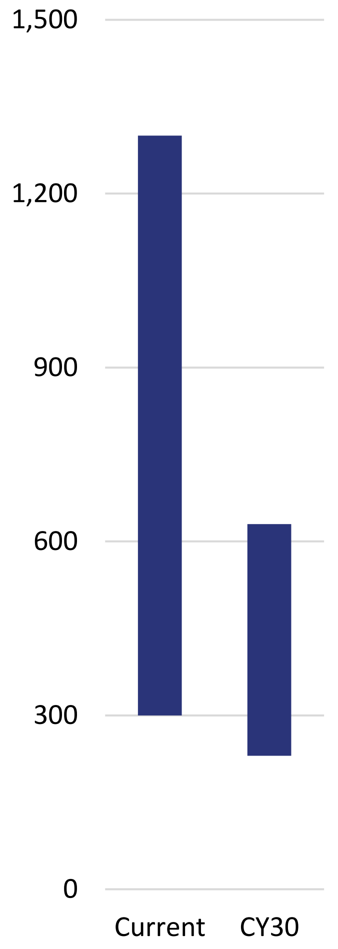
- **Cost trade-off between alkaline and PEM is not direct as the latter operates better under varying power conditions, reducing battery storage cost in the system. This could make capex for PEM lower than alkaline in certain cases, especially since alkaline requires higher space as well**
- **SOEC is an upcoming technology in large prototype phase, which has lower power consumption than other technologies. Its cost is typically above USD 2000/kW**

Source: CEEW, IEA, IRENA, Industry, SBICAPS

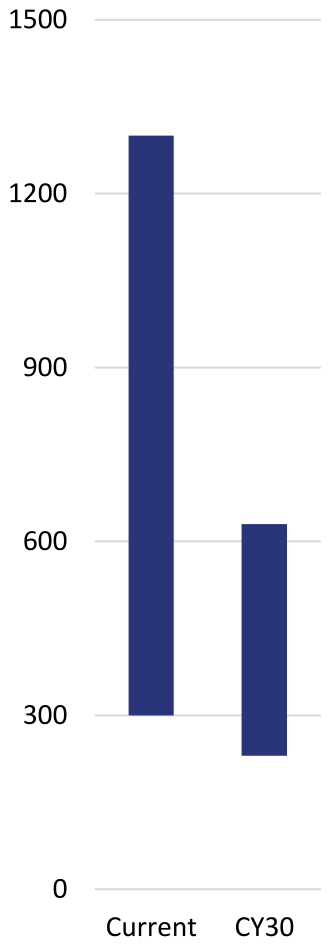
COST OF SETTING UP ELECTROLYSERS TO COME DOWN SIGNIFICANTLY

PROJECTED COST OF ELECTROLYSERS (USD/kW$_e$)

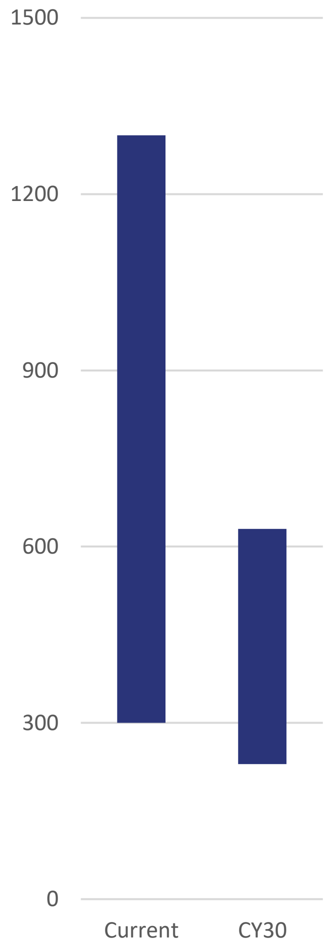
ALKALINE



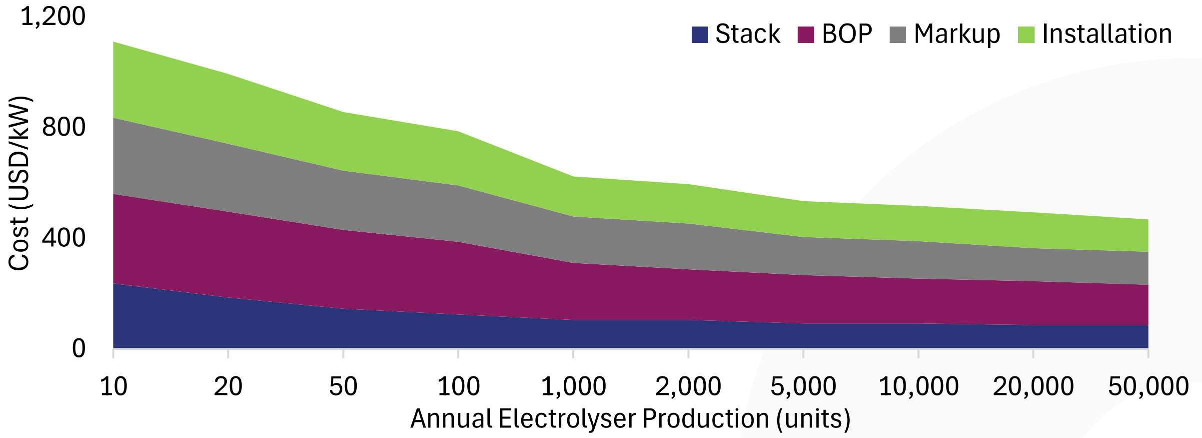
PEM



SOEC

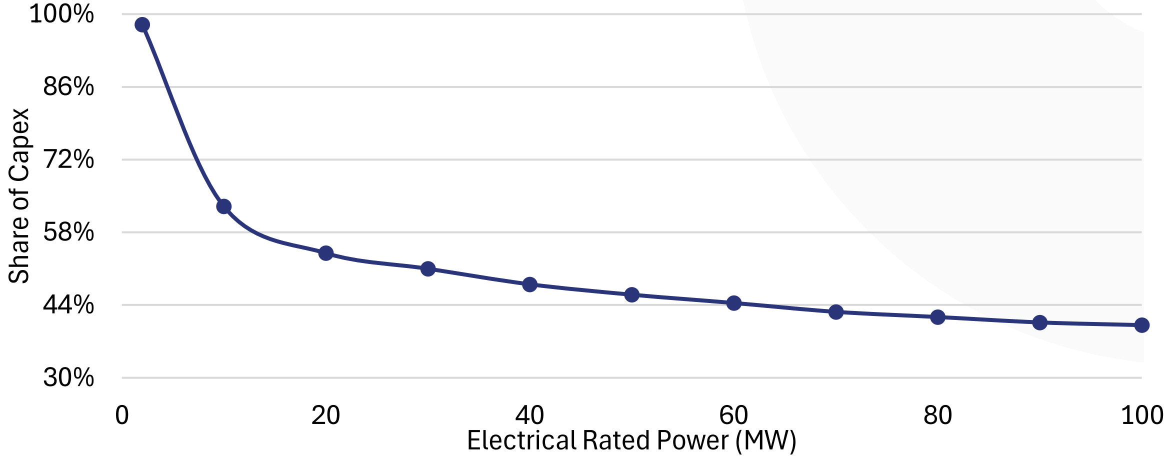


PRODUCING MORE ELECTROLYSERS IS CHEAPER*

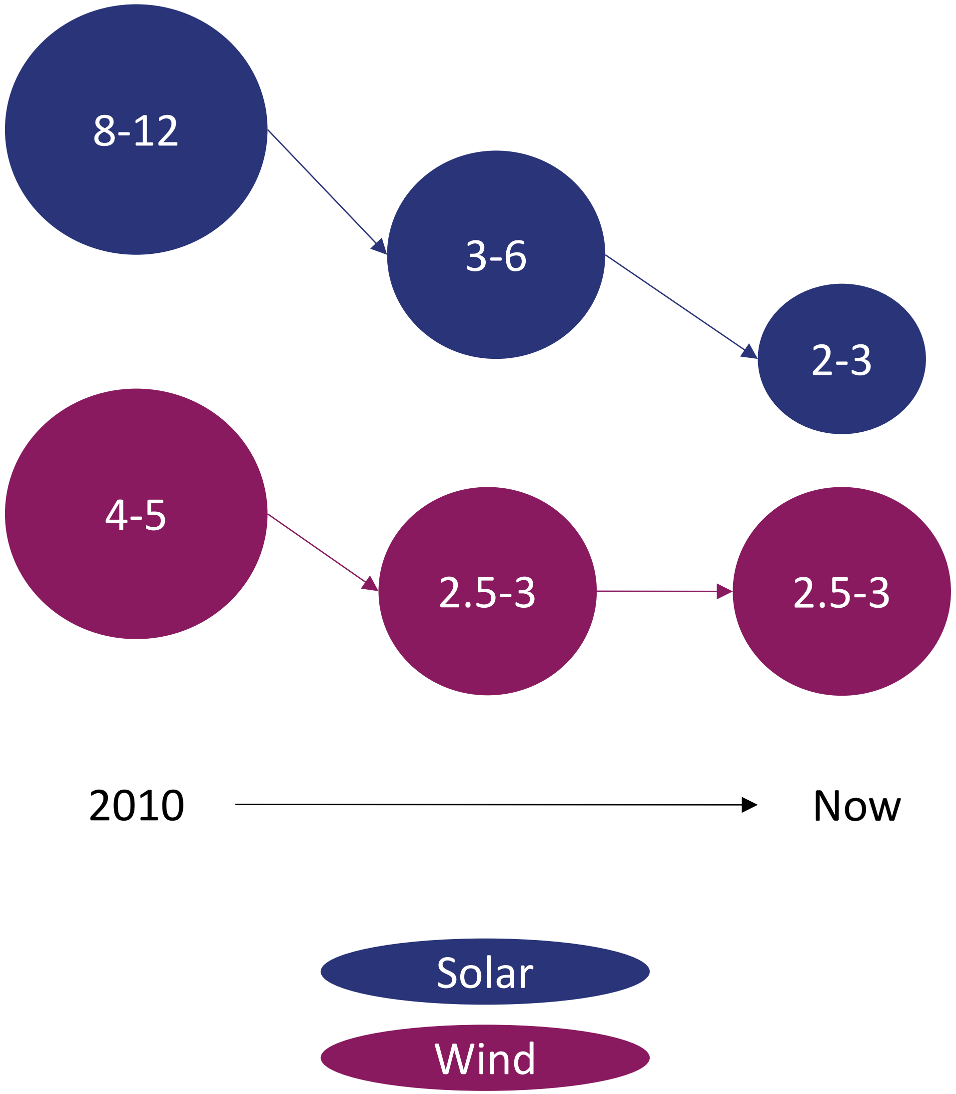


Note: Analysis for 1 MW PEM electrolyser

LARGER ELECTROLYSERS ARE MORE CAPEX EFFICIENT



AFFORDABLE & DIVERSE RENEWABLE SOURCES ARE KEY FOR HIGHER UTILISATION



Solar tariffs have dropped rapidly owing to declining module prices and improved technology

Wind tariffs started out lower, then dipped sharply due to reverse bidding. They have since stagnated due to low returns at these tariffs

~125 GW of renewables are expected to be needed just for NGHM by 2030

Given the requirement for constant renewable power, the role of wind and storage will go up when Green H_2 ecosystem develops – the exact mix various from project to project

Recent FDRE tariffs discovered of <Rs. 5/unit augur well for reducing the levelised cost of Green H_2 production

TECHNOLOGY EVOLUTION TO BRING DOWN GREEN H2 COSTS GLOBALLY

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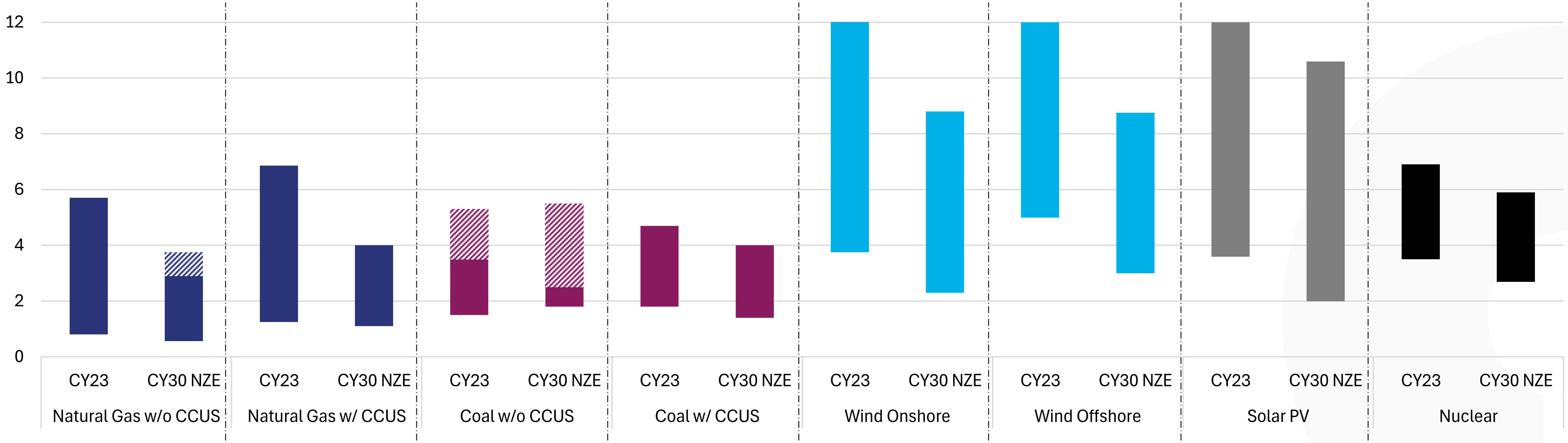
PROJECTED PRICE OF HYDROGEN BY COLOUR (USD/kgH_2)



Notes: 1. NZE = Net Zero Emissions by 2050 Scenario in 2030 2. The dashed area represents the CO_2 price impact, based on USD 15-140/t CO_2 for the NZE Scenario.

- **Factoring in carbon costs, the cost of producing green H_2 from solar will start becoming competitive with fossil fuel-based sources by 2030**
- **This will foster not only create new avenues of demand such as steel, transport etc., but also gradually replace existing places where H2 is used, such as fertiliser and refining industries**

Source: IEA, SBICAPS

FORE’SIGHT’ED INCENTIVES: GREENLIGHTING VIABILITY

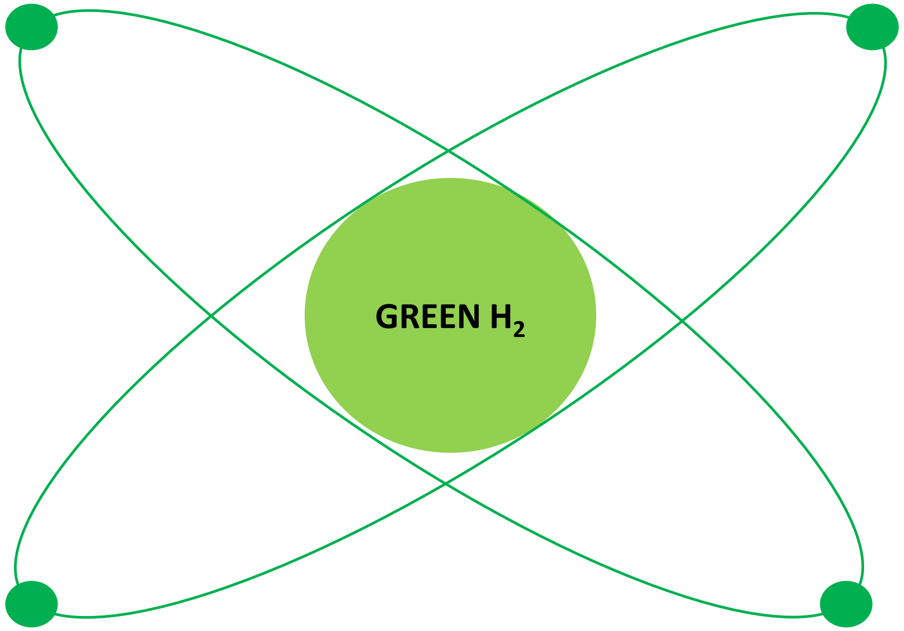
INDIA WELL POISED TO MAKE THE GREEN HYDROGEN LEAP

High Renewable Potential

- Total RE potential of 2.1 TW, amongst highest in the world
- Fair mix of wind (55%) and solar (36%), aiding 24x7 power
- Suitable storage potential for PSP, and upcoming BESS

Robust Domestic Demand

- India is a major consumer of fertilisers, petroleum, and steel: key end users
- These sectors are set to grow in India unlike other countries



Low Energy Cost

- RE cost at ~Rs. 2.5-3.5/unit is near lowest in the world
- FDRE tariffs (incl. storage) are also very cheap

Trade advantage

- 5 mn tonnes per annum of Green H2 by 2030 will lead to cumulative reduction in fossil fuel imports of over Rs. 1 trn
- Ample export potential to Europe, Japan

Adding strategic incentives to these inherent benefits could make green H_2 more viable

Source: CEA, WEF, PIB, SBICAPS

GREEN HYDROGEN TIMELINE: 'GREEN' SHOOTS

Feb 2021

NGHM announced by the Finance minister in the Union Budget

Feb 2022

Launch of Green hydrogen policy

Jan 2023

NGHM approved by the Cabinet

Jun 2023

SIGHT scheme incentives announced for electrolyzers manufacturing and green hydrogen/ ammonia

Aug 2023

Green hydrogen standards announced

Oct 2023

R&D Roadmap for Green Hydrogen Ecosystem in India

Jan 2024

SIGHT component-I: Incentives for electrolyzer manufacturing announced

Feb 2024

Scheme guidelines for pilot projects using hydrogen/green hydrogen in shipping. Steel and green transport

Mar 2024

Implementation of R&D scheme, setting up hydrogen hubs, scheme guidelines for skill development

Mar 2024

SIGHT component-II: Incentive for procurement of green hydrogen/ammonia production announced

Source: PIB, Ministry of Power, MNRE, Gazette of India, SBICAPS

SIGHT PROGRAMME COMPONENTS HAVE OVER'SIGHT' ACROSS THE VALUE CHAIN

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Scheme	Component 1	Component 2 Mode 1	Component 2 Mode 2A	Component 2 Mode 2B
End Product	Electrolysers	Green Hydrogen or its derivatives	Green Ammonia	Green Hydrogen
Basis of Bid	Highest index based on specific energy consumption and local value addition. Some preference to small players	Least average incentive demanded over 3-year period	Least cost for production and supply, fixed incentive and firm demand	Least cost for production and supply to refineries, fixed incentive and firm demand
Outlay (Rs. bn.)	44.4	130.5		
Implementation Agency	SECI	SECI	SECI	Oil & Gas Companies, CHT
Incentive	I = Rs. 4,400/kW in Year 1, progressively decreasing till Year 5 (Fixed incentive) I*min (allotted capacity, net sales of electrolysers)	I = Rs. 50/kg in Year 1, Rs. 40/kg in Year 2, and Rs. 30/kg in Year 3 (These represent upper caps, and developers must bid lower) I*min (allotted capacity, actual production)	I = Rs. 8.82/kg in Year 1, Rs. 7.06/kg in Year 2, and Rs. 5.30/kg in Year 3 (Fixed Incentive) I*min (allotted capacity, actual production)	I = Rs. 50/kg in Year 1, Rs. 40/kg in Year 2, and Rs. 30/kg in Year 3 (Fixed Incentive) I*min (allotted capacity, actual production)
Other Details	First Tranche of 1,500 MW: • Bucket 1: 1,200 MW (any stack) • Bucket 2: 300 MW (indigenous stack technology) Second Tranche of 1,500 MW: • Bucket 1: 1,100 MW (any stack) • Bucket 2: 300 MW (indigenous stack technology) • Bucket 3: 100 MW (indigenous stack technology – smaller units)	Each Tranche of 450 ktpa: • Bucket 1: 410 ktpa (technology agnostic) • Bucket 2: 40 ktpa (biomass pathway) Two tranches launched till now	First Tranche of 550 ktpa, enhanced in Jun'24 to 750 ktpa Actual tender in Tranche 1 of 539 ktpa (live tender)	First Tranche of 200 ktpa

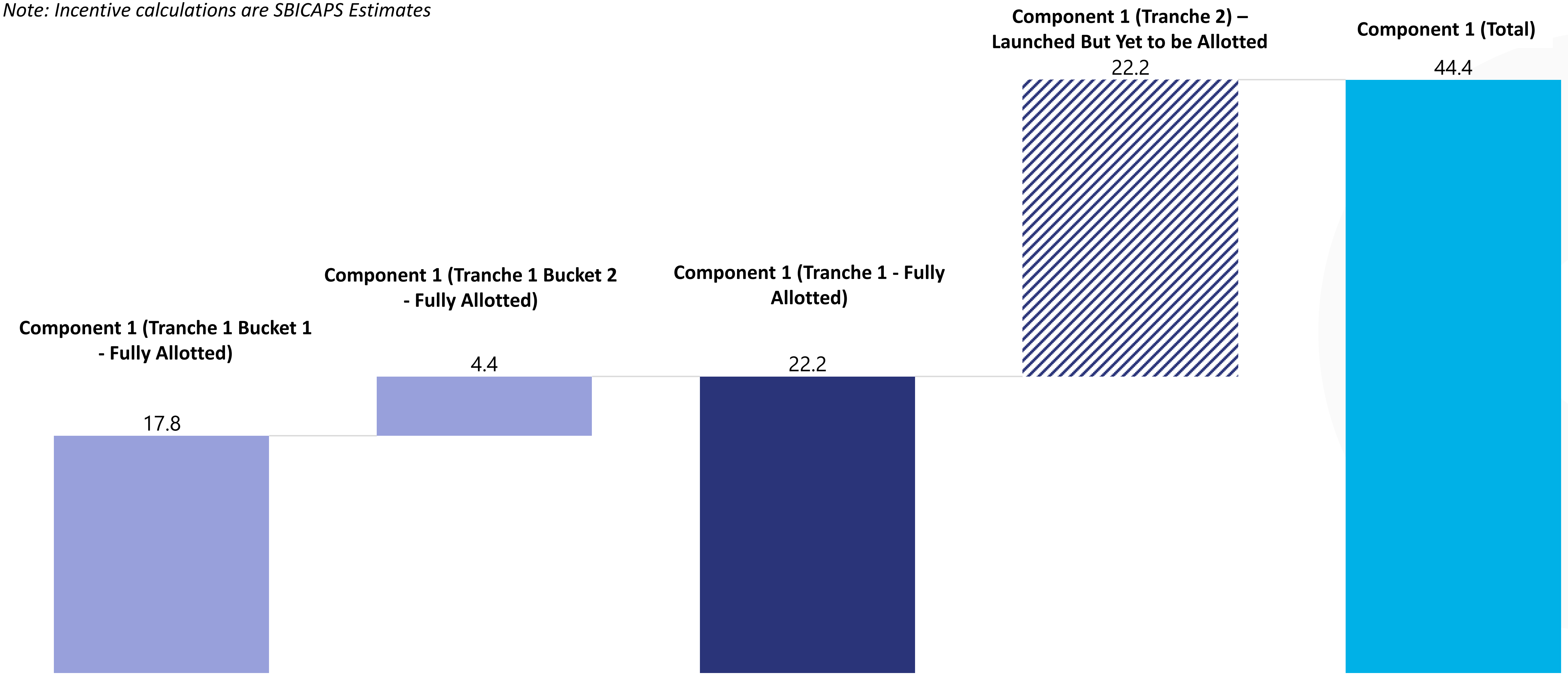
TOTAL OUTLAY
Rs. 175 bn

Source: MNRE, SBICAPS

ELECTROLYSER COMPONENT FULLY LAUNCHED

INCENTIVE ALLOCATION FOR SIGHT COMPONENT 1 (Rs. bn.)

Note: Incentive calculations are SBICAPS Estimates



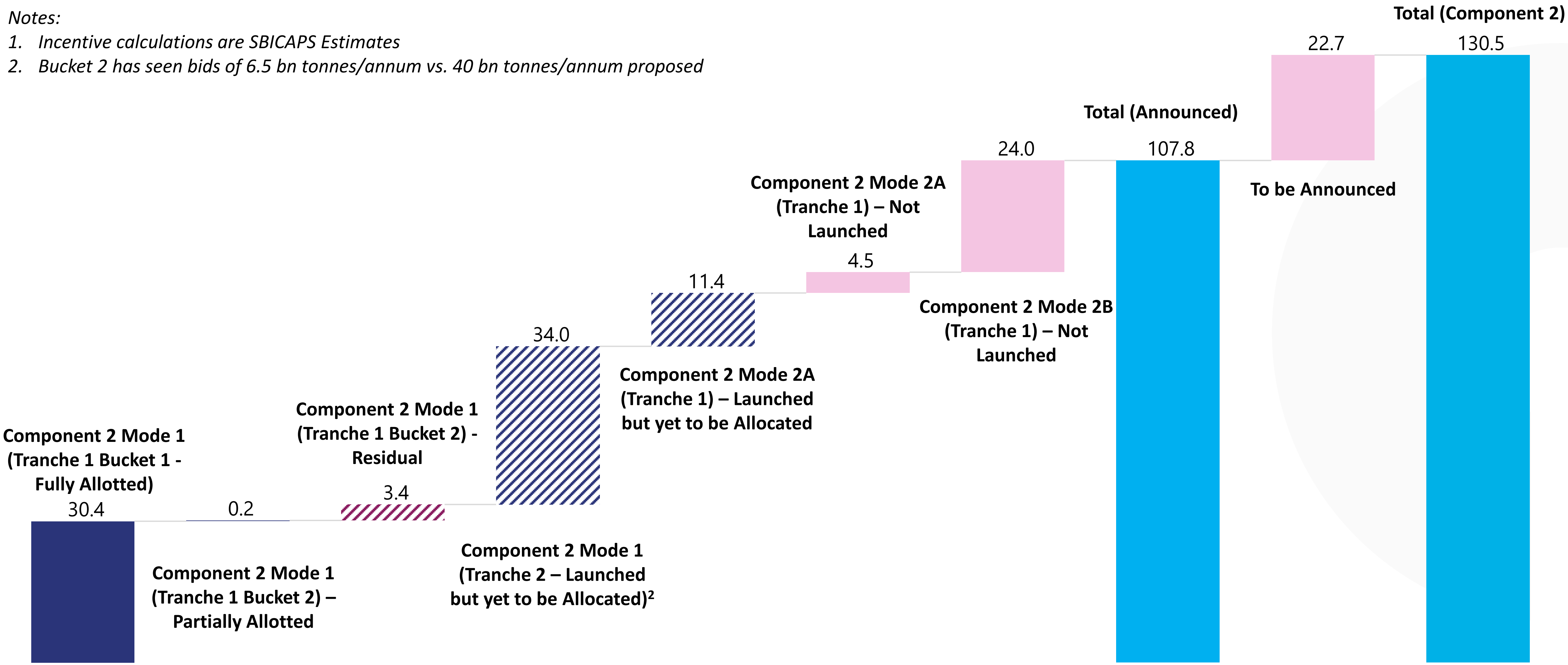
Source: MNRE, MERCOM, News Sources, SBICAPS

>75% IN COMPONENT 2 YET TO BE COMMITTED

INCENTIVE ALLOCATION FOR SIGHT COMPONENT 2 (Rs. bn.)

Notes:

1. *Incentive calculations are SBICAPS Estimates*
2. *Bucket 2 has seen bids of 6.5 bn tonnes/annum vs. 40 bn tonnes/annum proposed*



CURRENT WINNERS: A MOTLEY MIX OF SPECIALISTS AND END USERS

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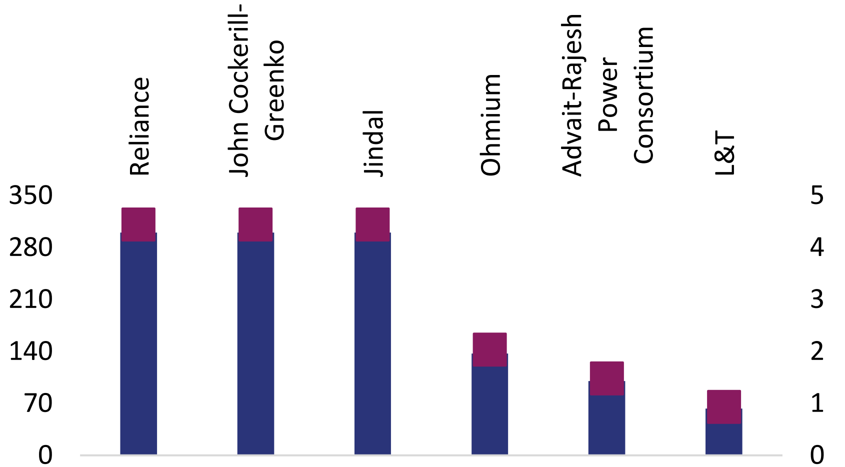
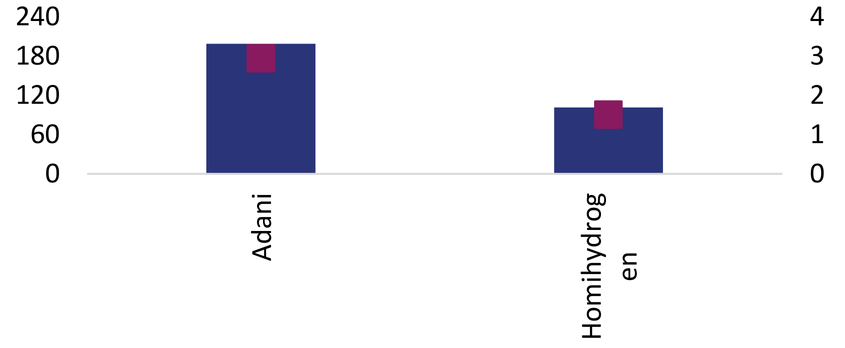
ELECTROLYSER | **GREEN H2** | **DERIVATIVES**

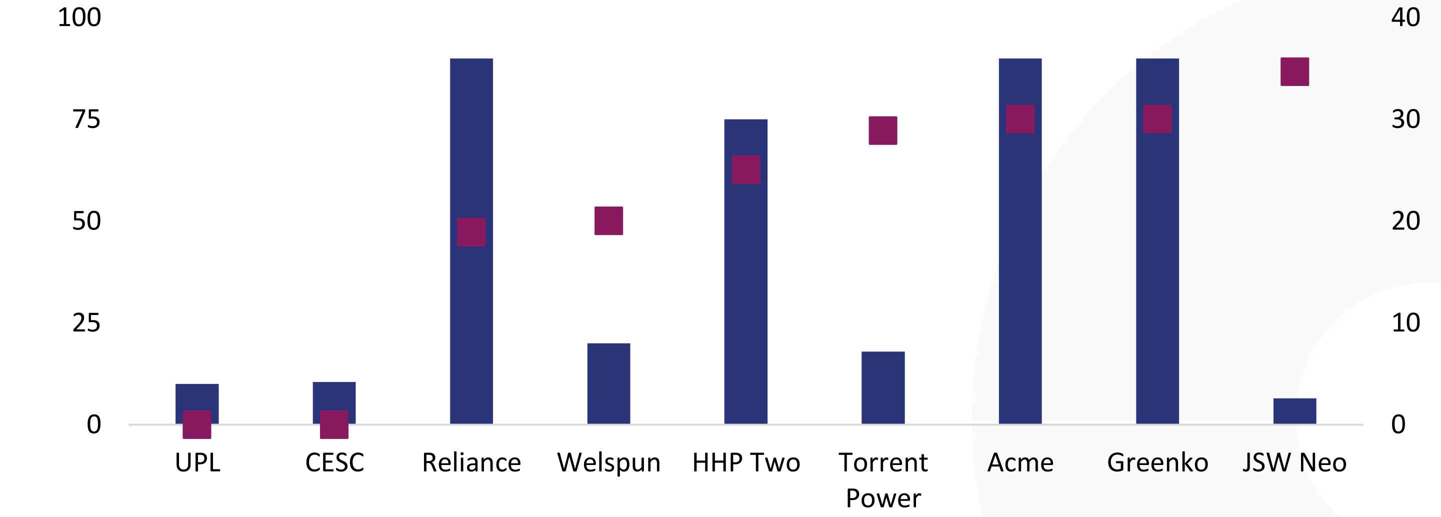
ANY STACK



INDIGENOUS STACK



ANY PATHWAY



BIOMASS PATHWAY