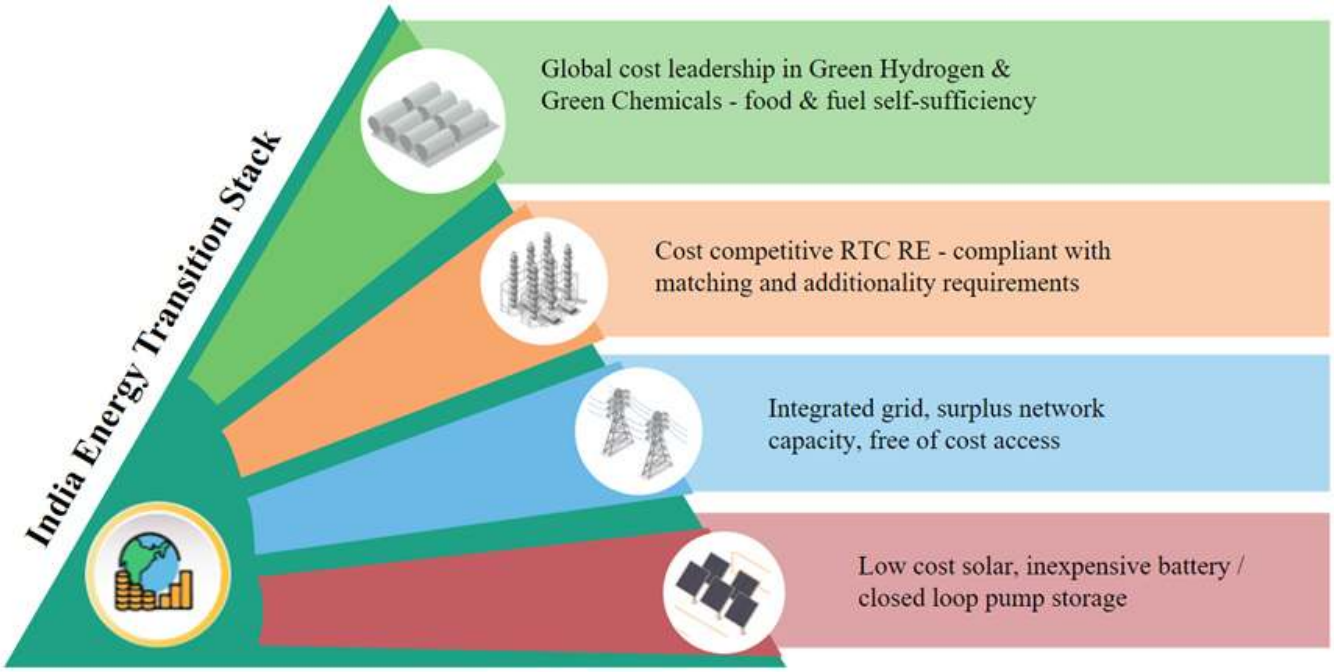
#1 Positioning Grid as the base of India's Renewable Energy Transition

Robust, integrated electricity transmission grid driving India's RE transition; key to New Energy cost leadership: When we noted India's global cost leadership in generating Round-the-clock Renewable Energy (RTC RE) in our **sector initiation note**, our assessment was not only driven by purely natural / geographical factors like solar irradiation or wind speeds. Unlike most other similar sized countries, a key enabler is India's large, integrated national transmission grid, which allows developers to tap the most favorable renewable generation and pumped storage sites, free of cost.

We believe that India needs to view its electricity transmission grid like the base layer of a stack, on top of which multiple new business models and solutions for decarbonisation will be built. We believe keeping grid access free of cost for new and renewable energy projects for an extended period, will yield net benefits at system-level, over time.

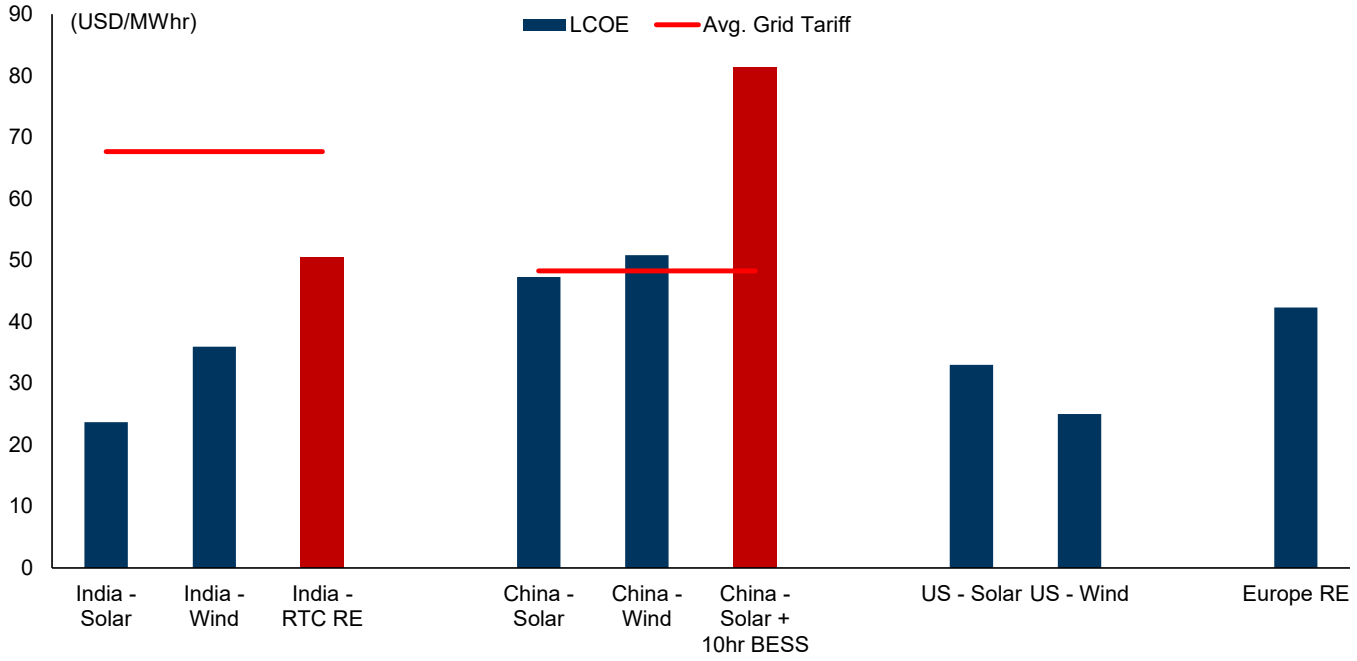
Exhibit 14: GS's India Energy Transition Stack
Path to country's food & fuel security, new energy cost leadership and decarbonisation



Source: Goldman Sachs Global Investment

Each layer in our India Energy Transition Stack is inter-linked and inter-dependent - highlighting the importance of cross-discipline / cross-department planning and policymaking to attain food and fuel self sufficiency.

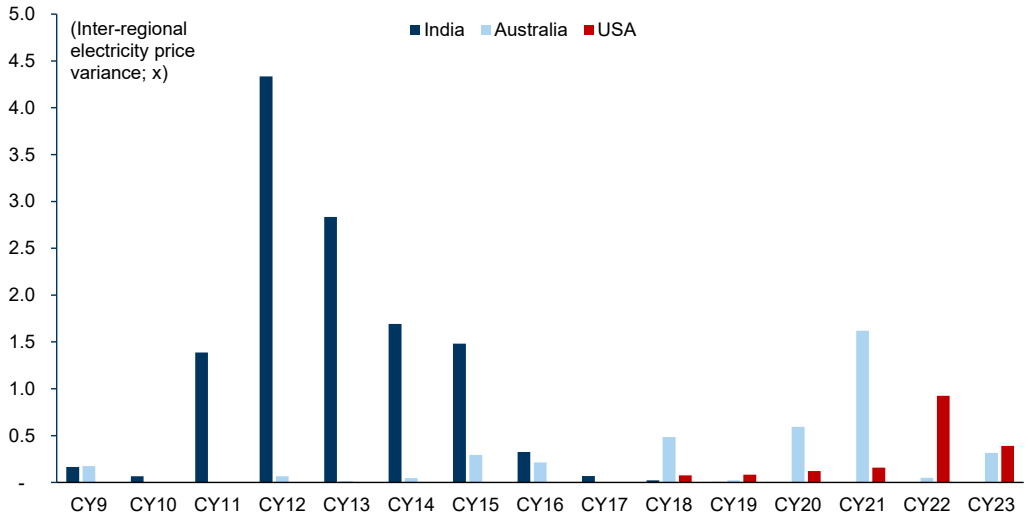
Exhibit 15: India's global competitiveness in firm renewable energy is driven by its geographical advantage (inexpensive solar power) combined with the unconstrained ability to tap best locations for RE & storage projects - enabled by its vast, integrated power grid



* LCoE - Levellised Cost of Electricity; as on Mar'24

Source: Goldman Sachs Global Investment Research

Exhibit 16: Limited variance in inter-regional electricity prices since CY15 coincides with pick up in India's first major transmission capex cycle - highlighting the high level of integration of the national grid viz.-a-viz. USA & Australia



Source: AEMO, US Bureau of Labor Statistics, IEX, Goldman Sachs Global Investment Research

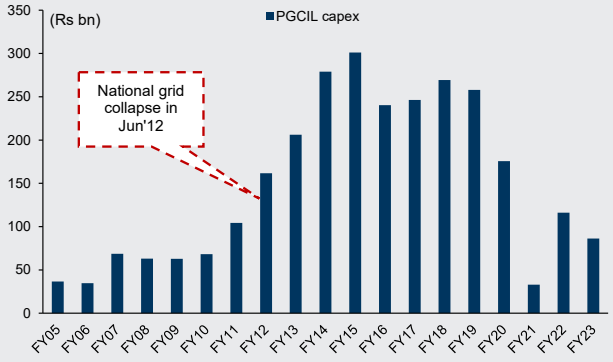
Case study: How over-building of grid in the recent past helped India add c.70GW solar without corresponding transmission capex

A grid collapse led to national blackout in Jul'12, affecting over 600mn people, forced the central government to materially ramp up grid upgrade capital expenditure over the next 8 years. The sheer quantum of this capex was so high that Power Grid's (PGCIL) asset base increased 4x, during this time period. Its cashflows were not able to keep pace with equity requirement for growth, leading to PGCIL being over-leveraged (net gearing of more than 70%) in 6 out of those 8 years.

As a result, by the end of this capex cycle, it appeared that India had made its national grid future-ready for the foreseeable future. However, sharp rise in renewables (especially solar), coincided with this phase of surplus transmission capacity, allowing the government to offer it free of cost for facilitating renewable adoption.

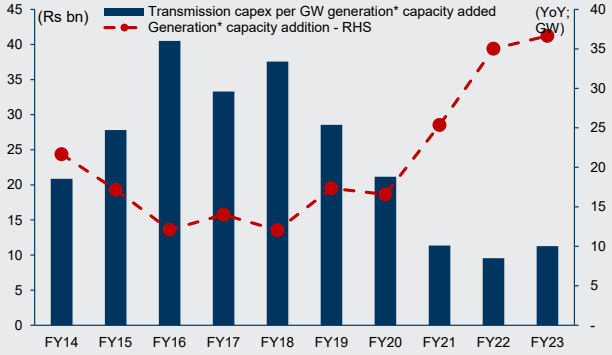
In our view, what began as a happenstance, has turned into India's core-competency in the ongoing energy transition.

Exhibit 17: Power Grid's annual capex increased materially post the national grid collapse in Jul'12...



Source: Company data, Data compiled by Goldman Sachs Global Investment Research

Exhibit 18: ...which aided in RE capacity addition b/w FY14-23 without corresponding increase in transmission capex



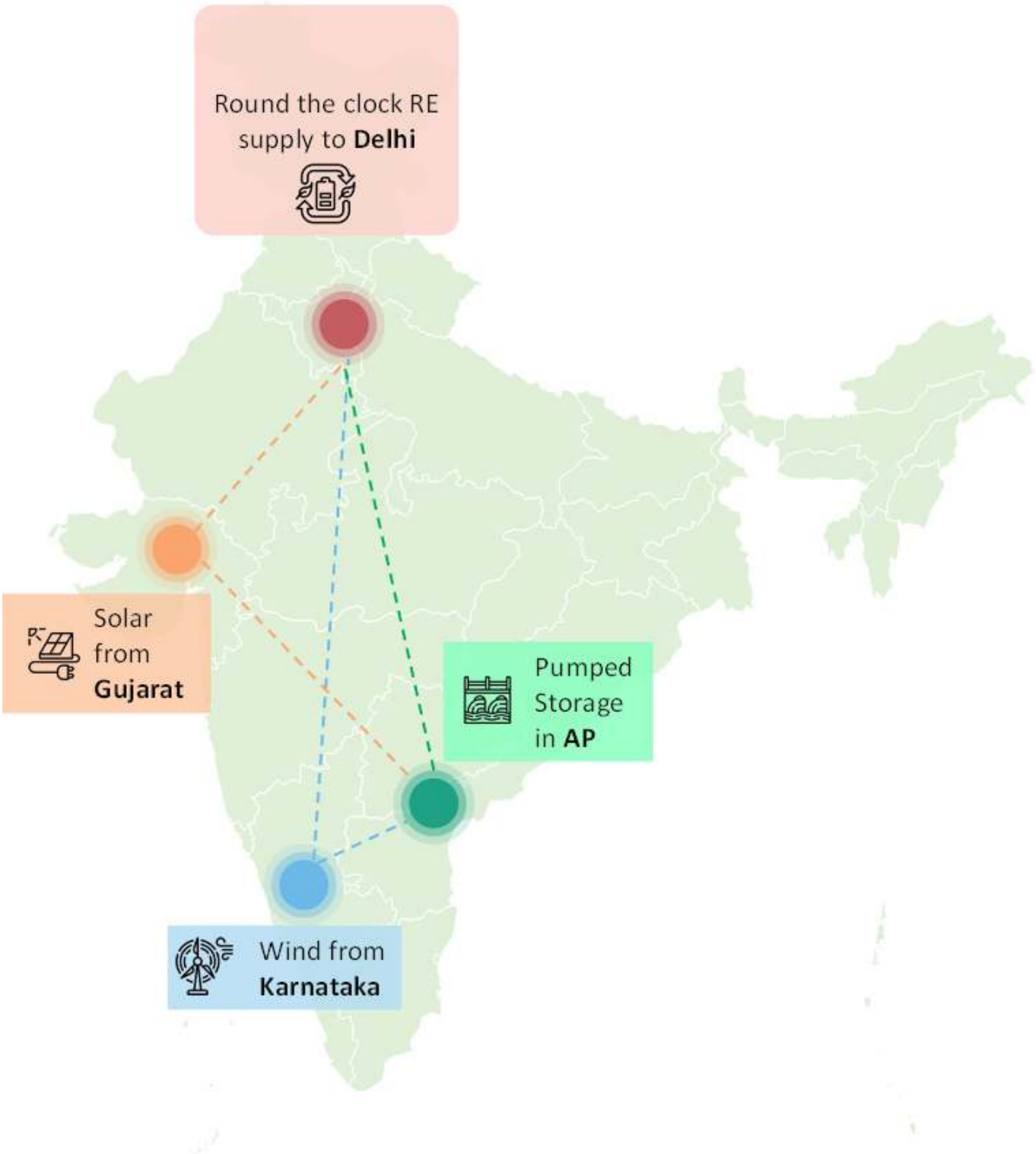
*Generation capacity addition is 3yr fwd – to factor the execution timeline of transmission projects

Source: CEA, Goldman Sachs Global Investment Research

Adequate network capacity, free of cost grid access enhancing RE cost competitiveness, unlocking new business models: By overcoming the constraint of geographical distance between demand and supply centers, India has been able to optimise its RE transition at a national scale, rather than being limited to local maxima. Not only has this helped minimise cost of plain vanilla renewable generation by allowing development of best sites, closed loop off stream pumped hydro storage, on which India is investing heavily, owe its viability to free national grid access in most cases.

Geographical de-linking of generation and storage locations has improved PSPs attractiveness against battery storage meaningfully, leading to creation of business models like storage-as-a-service, green open access, de-centralised green hydrogen production etc.

Exhibit 19: ndia's highly integrated national grid allows seamless transfer of RE across the country – unlocking new business models like Storage as a Service

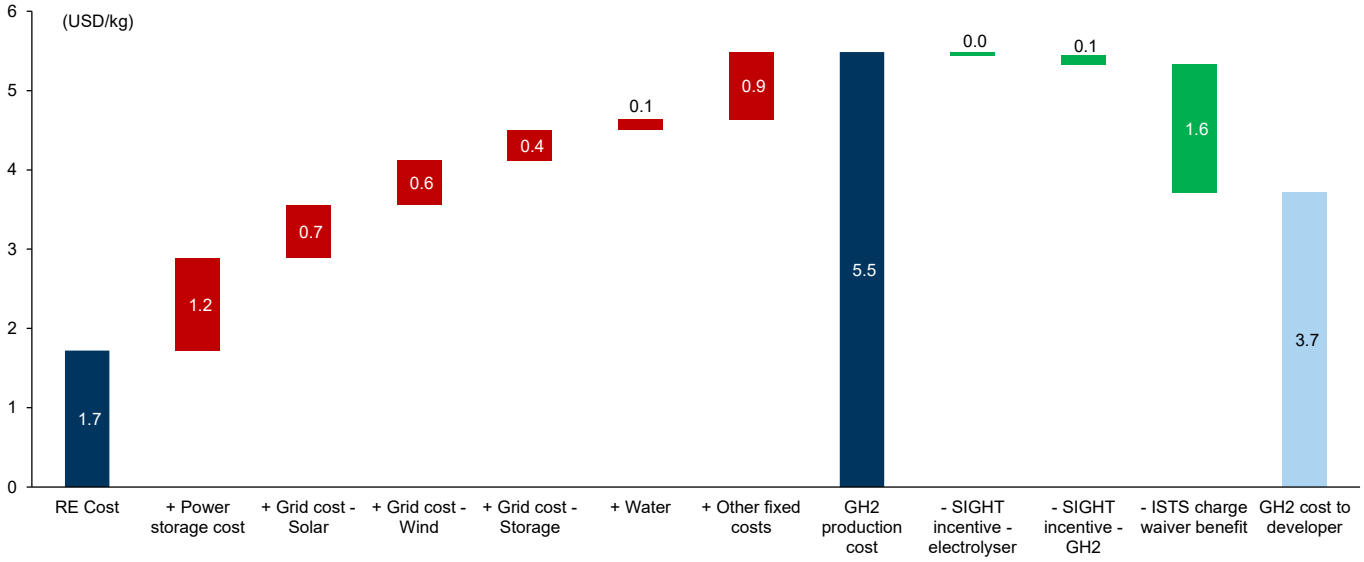


Source: Goldman Sachs Global Investment Research

Transmission cost waiver critical for India New Energy cost leadership: Central grid charge waiver offers 3 types of incentives for green hydrogen (GH2) production in India:

1. c.40% direct cost reduction by allowing PSP backed RTC RE to be delivered at electrolyser location - 10x the 4% LCoH benefit delivered by SIGHT auctions.
2. Free grid access allows high electrolyser utilisation (on RTC RE) - which is the most cost effective GH2 production strategy currently (vs. electrolyser oversizing on solar only with GH2 storage & co-located electrolyser with solar, wind & BESS).
3. By allowing RTC electrolyser operation at GH2 consumption centers, grid charge waiver minimises GH2 storage & transportation requirement - est. worth USD24bn.

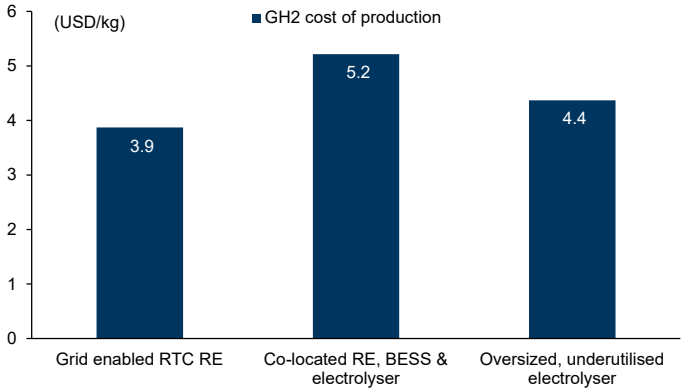
Exhibit 20: Central grid charge waiver help bring down India's Green Hydrogen cost by 40%+, while incentives offered on electrolyser & green hydrogen production under the flagship National Hydrogen Mission are expected to help reduce cost by c.4%



* RE - Renewable, GH2 - Green Hydrogen, SIGHT- Strategic Interventions for Green Hydrogen Transition Scheme, ISTS - Inter-state Transmission System

Source: SECI, CEA, MNRE, MoP, Goldman Sachs Global Investment Research

Exhibit 21: Of the three strategies for minimising LCoH, we estimate the one led by grid-enabled RTC RE to be most cost effective at current electrolyser prices



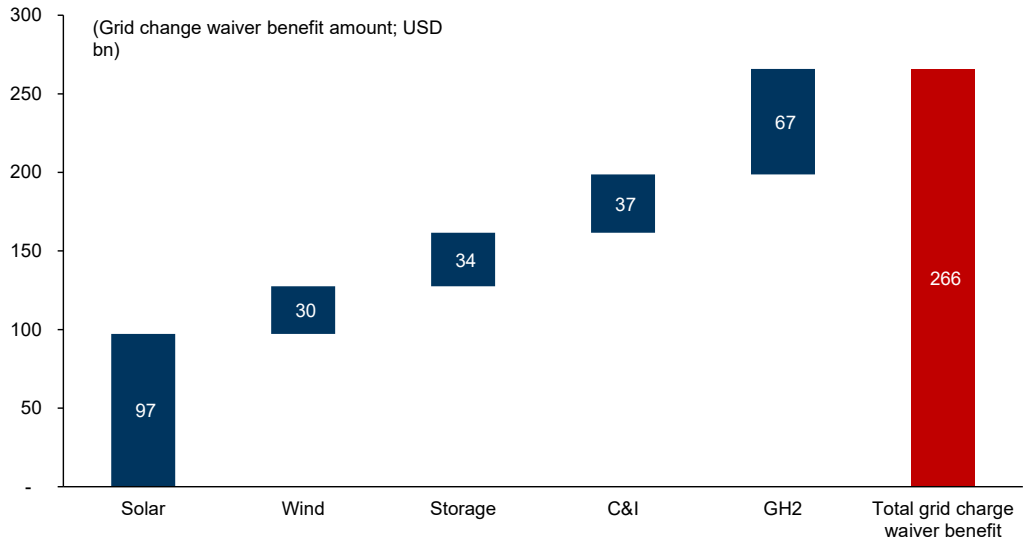
*RTC - round-the-clock, RE - Renewable Energy, BESS - Battery Energy Storage System

Source: Goldman Sachs Global Investment Research

#2 Free central grid access improving project economics, aiding renewable penetration

Incentive from India's transmission charge waiver equivalent to 25-35% of project capex, helping offset 15-40% cost for consumer: We estimate the implied incentive being offered to new and renewable energy in India through waiver of central grid charges at USD266bn across solar, wind, storage, corporate decarbonisation and green hydrogen.

Exhibit 22: India is providing a financial support worth c.USD270bn to new and renewable energy by waiving central grid charges
Estimated benefit b/w FY14-55

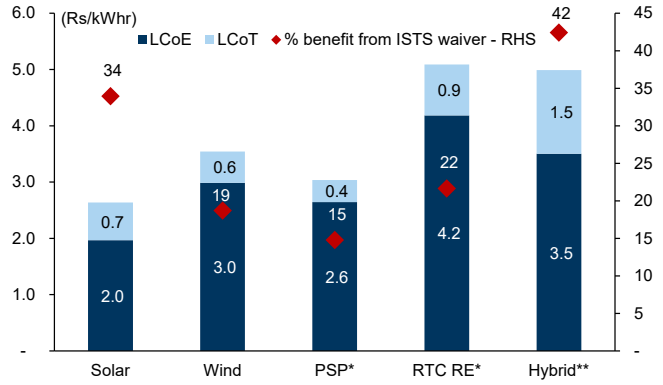


ISTS waiver benefit calculated assuming extension of waiver till end-FY30

Source: MoP, Goldman Sachs Global Investment Research

...translating into 25-35% implied capital subsidy / 15-40% per unit subsidy for consumer...: We estimate India's central grid charge waiver translates into a financial benefit equivalent to 25-35% of capex / 15-40% of per unit cost of various sources and configurations of renewable power generation and storage.

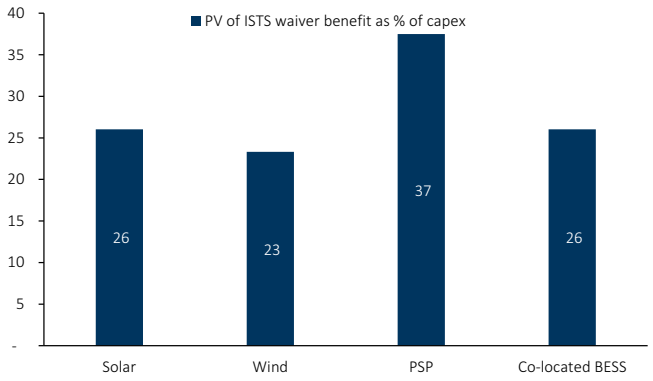
Exhibit 23: Central grid charge waiver helps offset 15-40% of cost for renewable / storage capacities vs. conventional generation…



*LCoE - Levellised Cost of Electricity; LCoT - Levellised Cost of Storage; ISTS - Inter State Transmission System / National Grid; *RTC RE (Round-the-Clock Renewables) - LCoS is based on assumption of 1.5x storage cycle / day from pumped storage; ** hybrid project est. based on Renew's 400MW RTC tender; as on Mar'24

Source: SECI, Goldman Sachs Global Investment Research

Exhibit 24: …which translates to implied capex subsidy of 25-35% for RE / storage projects



*as on Mar'24

Source: Goldman Sachs Global Investment Research

...while also improving equity returns for developers...: By unlocking new business models and allowing novel project configurations, central grid charge waiver aids in improving the financial viability of RE projects.

Case study: How national grid charge waiver helped improve Renew's IRR in 400MW RTC project

India's first round-the-clock renewable energy supply project, RTC-I was tendered by Solar Energy Corporation of India (SECI) in 2019. The project entailed 400MW of electricity supply, with minimum annual capacity utilisation factor (CUF) of 80% and minimum monthly CUF of 70%.

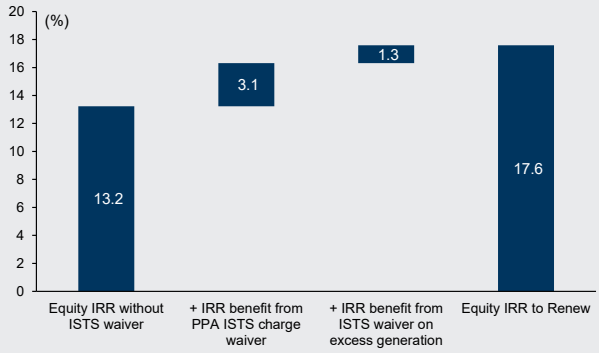
Renew (RNW.US; Buy) emerged as the lowest bidder in the reverse e-auction, seeking a tariff of Rs2.9/kWhr in first year of supply with 3% annual tariff escalation upto year 15 - resulting in a levelised tariff of c.Rs3.5/kWhr.

While the tender did not require on-demand despatch of electricity by developer, the minimum CUF requirement and allowance to inject power from multiple locations in the grid, resulted in significant capacity oversizing. For supplying 400MW electricity, Renew is setting up 1300MW generation (400MW solar + 900MW wind; across multiple locations) and 100MWhr storage capacity.

In our assessment, not only did the capability of central grid access across multiple geographical locations made this very generation capacity configuration possible, waiver of grid charges added as much as c.450bps to the developer's equity IRR. Of this 450bps benefit, 300bps+ could be directly attributed to transmission charge waiver for the excess grid infra being utilised by over-sizing of capacity to meet tender's CUF norms, c.130bps benefit is on account of even the surplus renewable generation (GSe of c.40% of PPA generation) being entitled to grid access free of cost.

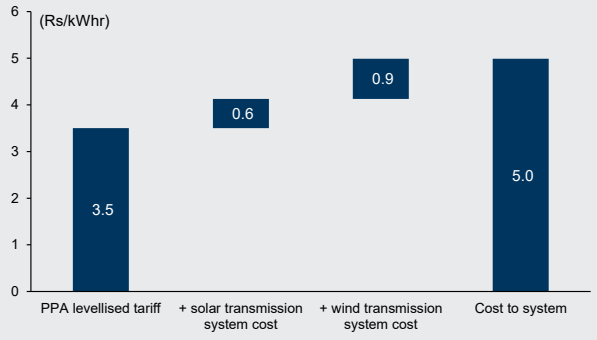
Factoring the socialised cost of transmission in this project, we estimate the total system cost at Rs5/kWhr - 43% higher than the levelised tariff of Rs3.5/kWhr.

Exhibit 25: Central grid charger waiver has helped improve Renew's equity IRR in a RTC project by as much as 450bps…



Source: SECI, Goldman Sachs Global Investment Research

Exhibit 26: ...with 30% of the system cost being socialized among other users of the national grid



Source: SECI, Goldman Sachs Global Investment Research

...at the same time, making decarbonisation cost competitive: In our **Jul'23 sector initiation note** on generation companies, we had noted that our calculations suggest pumped hydro backed RTC RE power is already cheaper than the average 'green tariffs' offered by DISCOMs to commercial and industrial consumers. This cost advantage, along with the corporate push for achieving net zero opens a significant capacity addition opportunity for RE developers.

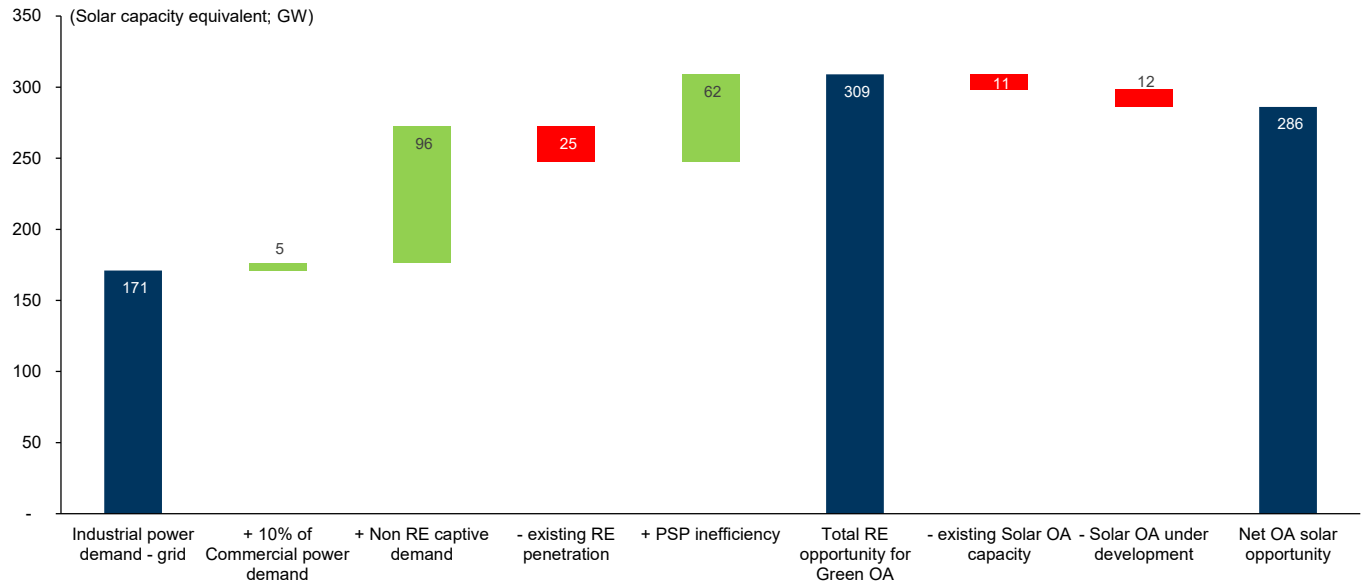
As per our estimates, India's levelised cost for RTC RE is currently 27% lower than that of China, driven by cheaper RE costs overall. When combined with India's higher average grid tariff vs. that of China, it begins to make economic sense for consumers (especially corporates, which are charged even higher grid tariffs) to shift to RTC RE. Similarly, India has a materially lower RE LCoE (Levelised Cost of Electricity) vs. Europe and it is competitive with that in US, despite having a significantly higher cost of debt (key cost item for RE projects).

Industrial and commercial users constitute c.50% of India's overall electricity demand and fully transitioning them to RE could unlock a solar equivalent capacity addition opportunity worth 295GW at materially superior returns and lead to an improvement in customer profile from financially struggling DISCOMs to credit-worthy corporates.

At the time of our note, Corporate and Industrial consumers had open access renewable installations of c.10GW, while another 4GW were under development. Since then, installations have crossed 11GW with another 12.5GW open access projects under development. Our analysis of various filings suggests central grid connectivity requests worth c.30GW by various large industrial consumers.

This sharp pick up has happened without much government coercion or subsidisation, but because it was driven by economic rationale, in turn made possible by 2 government policies - 1) Green Open Access: which allows consumers above 100kw of load to directly purchase power from renewable developers bilaterally, and 2) Direct central grid access to large industrial consumers, bypassing the state T&D infrastructure. Both of these were aimed towards limiting the state's ability to utilise physical infrastructure as a constraint on energy cost optimisation, given the perverse retail tariff structure in India across most states.

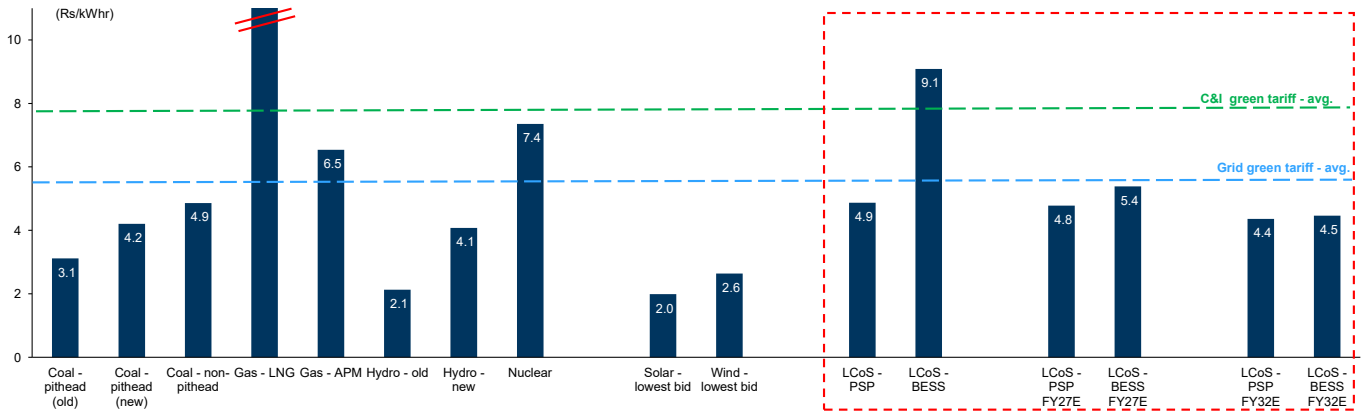
Exhibit 27: c.300GW solar capacity equivalent opportunity from Corporate & Industrial decarbonisation



*OA - Open Access; as on Mar'24

Source: CEA, Goldman Sachs Global Investment Research

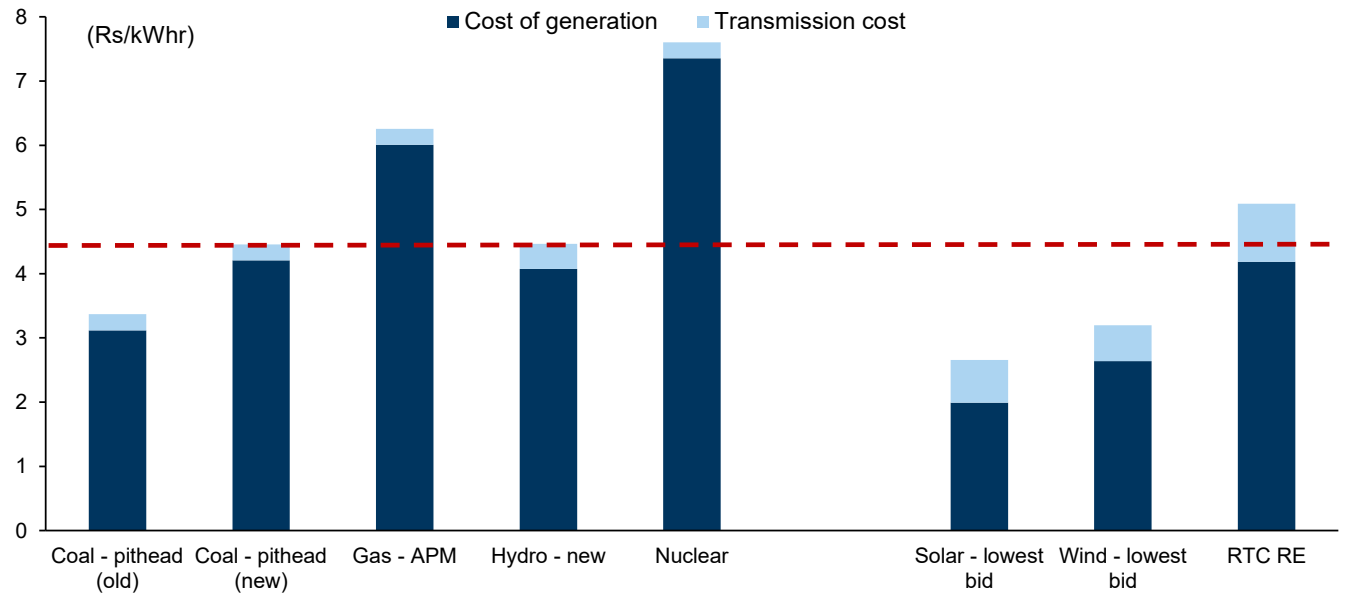
Exhibit 28: India electricity cost curve - levelised cost of RE backed pumped storage already at par with non-pithead based coal plants
Cost of electricity generation / storage across various modes



*LNG - Liquified Natural Gas, APM - Adjusted Price Mechanism, BESS - Battery Storage, PSP - Pumped Hydro Storage, RTC RE - Round-the-Clock Renewables; as of Mar'24

Source: Goldman Sachs Global Investment Research, CEA

Exhibit 29: In our estimate, central grid charge waiver is instrumental in driving cost competitiveness of 24X7 renewables vs. fossil fuel based generation - helping facilitate decarbonisation

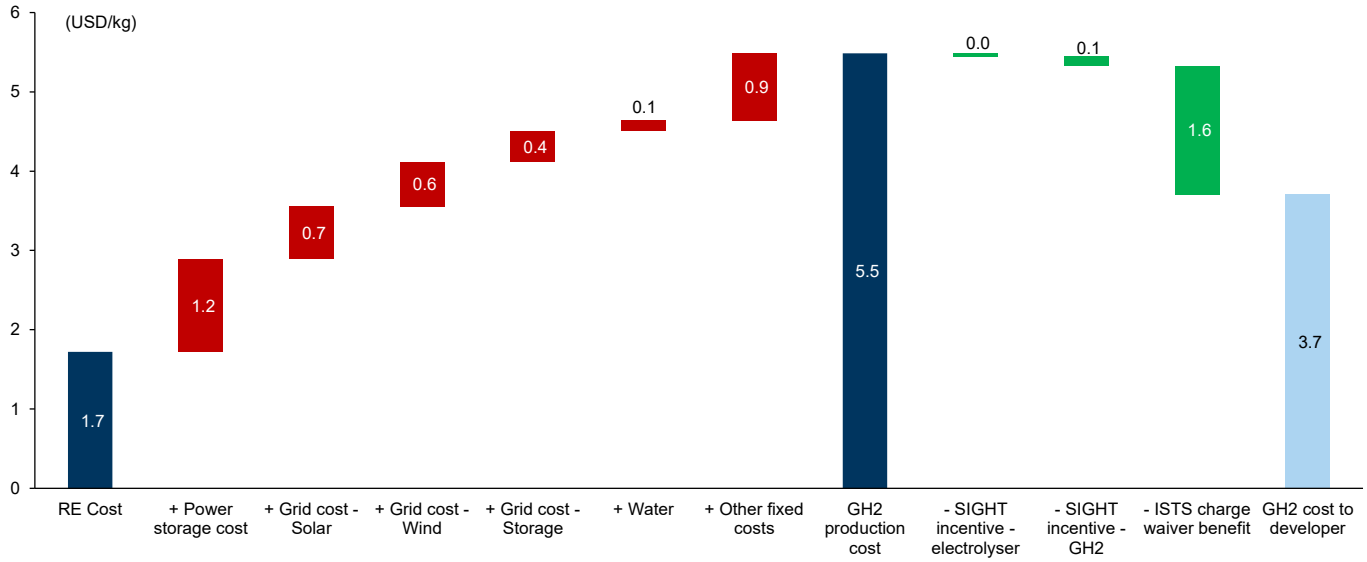


Source: CEA, Goldman Sachs Global Investment Research

Even beyond direct electrification, we believe adequate grid capacity and charge waiver will be critical in driving India's global cost leadership in green hydrogen and its derivatives. Central grid charge waiver offers 3 types of incentives for green hydrogen (GH2) production in India:

1. c.40% direct cost reduction by allowing PSP backed RTC RE to be delivered at electrolyser location. For context, the government's recently conducted subsidy auctions for electrolyser manufacturing and green hydrogen production under the SIGHT scheme yielded reduction in levelised cost of hydrogen of barely c.4%.
2. Indirectly, free national grid access allows higher electrolyser utilisation (by running it on RTC RE) - which, in our opinion, is the most cost effective among the 3 strategies for GH2 production (high electrolyser utilisation using RTC RE, low electrolyser utilisation on solar only with GH2 storage and co-located electrolyser with solar, wind and BESS).
3. By allowing round the clock electrolyser operation at GH2 demand / consumption centers, transmission cost waiver helps minimise requirement of GH2 storage and transportation - worth USD24bn, as per our estimate.

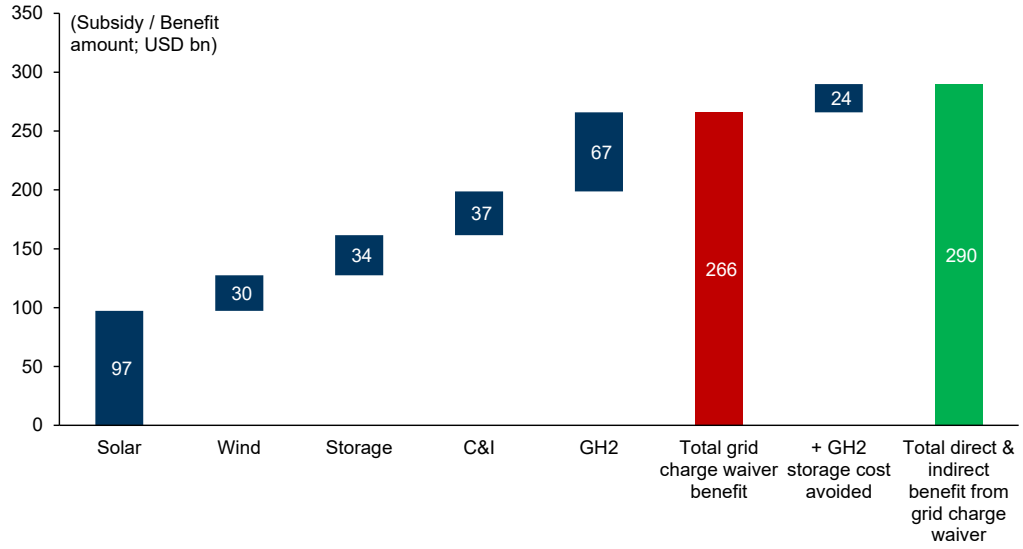
Exhibit 30: Central grid charge waiver will help bring down India's Green Hydrogen cost 40%+, materially improving its cost competitiveness globally. For context, incentives offered on electrolyser manufacturing and green hydrogen production under government's flagship National Hydrogen Mission are expected to help reduce cost by c.4%



* RE - Renewable, GH2 - Green Hydrogen, SIGHT- Strategic Interventions for Green Hydrogen Transition Scheme, ISTS - Inter-state Transmission System

Source: SECI, CEA, MNRE, MoP, Goldman Sachs Global Investment Research

Exhibit 31: In addition to the USD266bn direct incentives / benefits being offered by India's national grid charge waiver, we estimate additional USD24bn incentive being implied by de-cetralised electrolyser installations at demand centers - helping avoid capex required for green hydrogen storage

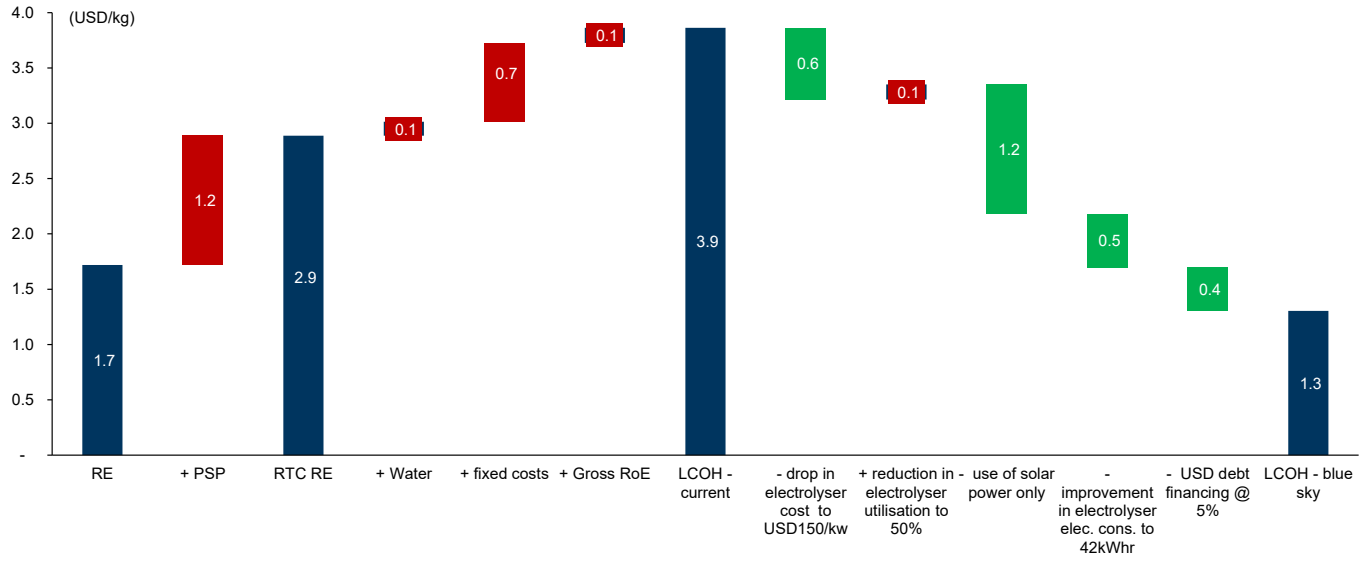


ISTS waiver benefit calculated assuming extension of waiver till end-FY30

Source: MoP, Goldman Sachs Global Investment Research

Over the longer term, we view GH2 cost commoditisation in India to require oversizing and under-utilisation of electrolysers, essentially running them only on least cost solar generation. This switch, will require capital cost of electrolysers and GH2 storage to tip below the cost of storage backed RTC renewable generation, in addition to technological advancements in electrolyser's capability in managing intermittent solar power supply along with sharper ramp rates. However, if and when this happens, we believe it will further increase GH2's transmission intensity as oversizing of electrolysers will require overbuilding of solar generation capacity, in turn driving larger transmission network build-outs.

Exhibit 32: Path to green hydrogen cost reduction, in our opinion, is through oversizing and under-utilisation of electrolysers - which, in turn, will require much larger transmission network build out to avoid power storage costs



Source: Goldman Sachs Global Investment Research