

Initiation

India Clean Energy

Balancing Growth with Decarbonisation

India's electricity sector is undergoing a generational shift in our view, as the country attempts to grow and decarbonise, simultaneously. Years of peak demand growth (rising electrification and appliances penetration) alongside less reliable capacity additions (renewables accounted for c.75% of new power capacity additions in the last 7 years) have absorbed the system's supply surplus. **We foresee the beginning of a peak power deficit cycle, elevating the criticality of storage-backed round-the-clock renewable energy (RTC RE).** Our analysis suggests the **viability of RTC RE in certain use cases** which will provide an economic incentive for transition, and **unlock a superior business model for utilities.** The need to balance energy security along with the transition would result in a premium for pumped hydro storage (PSP) capacity. We also see upside risk to our and the government's coal capacity targets, which could lead to a valuation re-rating of legacy thermal businesses. We highlight 4 key inferences:

#1 Superior return profile of PSP-backed RTC RE (20-25% equity IRR vs. 13-15% for solar & coal) can structurally improve the business model of utilities.

#2 c.400GW 'economically viable' RE capacity potential with corporates shifting to net-zero compliant and economically viable RTC RE supply, alongside the solarisation of agricultural power supply. This is a unique opportunity for India vs. other large economies. For context, we estimate RTC RE viability in China closer to 2030E despite it being self-sufficient in RE & batteries.

#3 Our India Stationary Storage Demand model estimates **c.600GWhr storage demand by FY32E**, but India will **meet only c.80% of it** even in an optimistic execution scenario. Consequently, **India may need to add c.23GW more coal capacity** than what government targets.

#4 Public Sector Undertakings are uniquely positioned in the RE business with equity IRR advantage of 150-200bps given their significant structural funding cost advantage backed by large balance sheets.

Apoorva Bahadur
+91(22)6616-9325
apoorva.bahadur@gs.com
Goldman Sachs India SPL

Nikhil Bhandari
+65 6889-2867
nikhil.bhandari@gs.com
Goldman Sachs (Singapore) Pte

Goldman Sachs does and seeks to do business with companies covered in its research reports. As a result, investors should be aware that the firm may have a conflict of interest that could affect the objectivity of this report. Investors should consider this report as only a single factor in making their investment decision. For Reg AC certification and other important disclosures, see the Disclosure Appendix, or go to www.gs.com/research/hedge.html. Analysts employed by non-US affiliates are not registered/qualified as research analysts with FINRA in the U.S.

Table of Contents

PM Summary	4
Thesis in 15 charts	7
#1 India's economics driven RE transition different from that witnessed elsewhere globally	13
#2 ...with the potential to disrupt 'Utility' business model, for the better	18
#3 But rising peak deficits will risk supply reliability...	21
#4 ...even as Pumped Hydro emerges as India's rescuer, ad interim	27
#5 Battery storage's cost disparity could force higher coal capacity addition	29
#6 Demand growth underperformance key risk to our thesis	34
Disclosure Appendix	37

India's unique economics-led renewable transition driving a business model upgrade; power storage critical but coal to stay relevant



Pumped hydro backed round-the-clock renewable power supply earns **1.5-2x returns** vs. plain vanilla solar and cost-plus coal plants



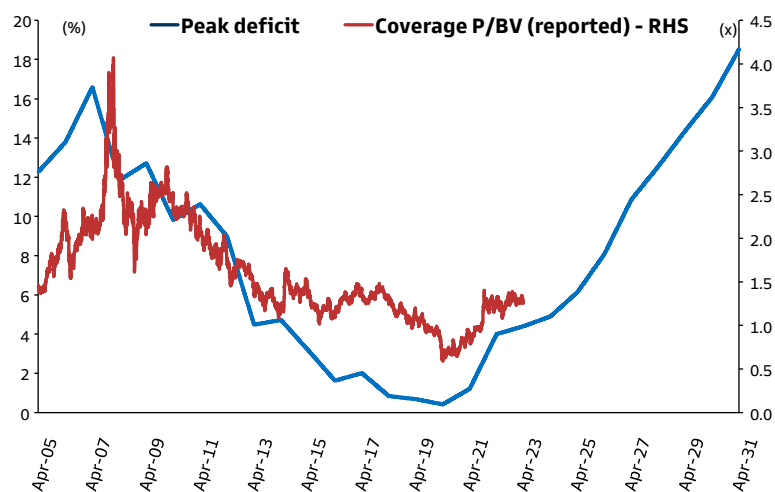
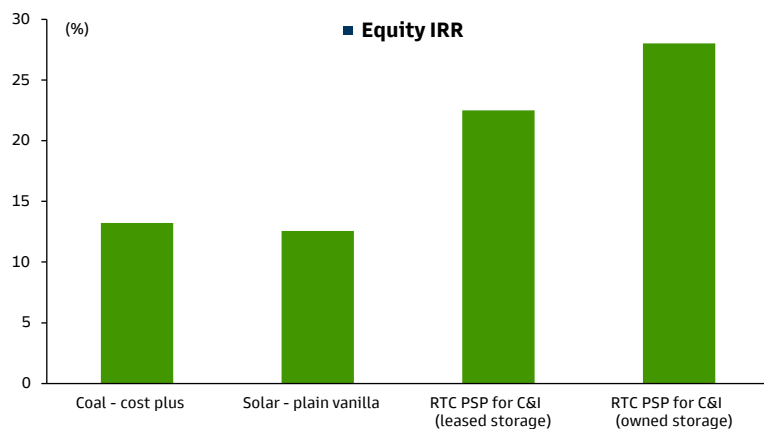
We see an economic case for **c.400GW** renewable capacity addition in India across corporate and agriculture sectors



Our India Peak Power Demand Supply model forecasts **47GW peak shortages by FY32E**, factoring firm capacity addition pipeline and plans



Our India Stationary Storage Demand model estimates **c.600GWhr storage demand** by FY32E but India will **meet only 80% of it** even in optimistic execution scenario – **requiring 50% more coal capacity addition** than govt. plan



Who stands to gain?



Public Sector Undertakings with significant funding cost advantage



Players with access to cost competitive storage capacity



Developers with firm (coal & hydro) untied capacities



Developers with ability to add de-risked (cost plus) fossil capacities to meet marginal demand while staying protected from risk of stranded investment

PM Summary

What makes India's Renewable transition different from the world?

1. We see an **economic case for RE transition** in India for certain use cases (TAM of c.400GW economics-supported RE capacity addition) vs. being mostly driven by government subsidies and incentives elsewhere, which can potentially enable **superior returns for developers**. While old pithead coal plants continue to lead the cost curve for reliable power supply, we estimate **PSP backed RTC RE power to cost only 15-17% more than new pithead coal plants** (negligible after factoring the transmission cost waiver). Further, this difference is expected to narrow over time due to inflation in coal and coal logistic costs.
2. The country will have to decarbonise while its electricity demand continues to grow. Unlike globally, **risk of stranded investments in India will be low** (as demand growth will ensure absorption of marginal capacities), ensuring supply reliability will remain challenging in an environment where the potential for sharp cost declines in up and coming technologies is high.
3. As per our estimates, India's levelised cost for **RTC RE is currently 27% lower than that of China**, on account of its higher solar irradiation and a fully integrated national transmission grid which allows utilisation of most optimal sites without evacuation constraints.

What are its implications?

1. We **anticipate a structural improvement in the business model of developers** on two fronts: a) higher returns from complicated RTC projects (20-25% equity IRR vs. 13-15% for plain vanilla solar and regulated coal projects), and b) improvement in customer base from financially weak state DISCOMs to corporates with better credit profiles.
2. **Phase of peak shortages has already started as the country added 71GW net firm capacity (thermal and nuclear) when peak demand rose by 80GW over the last 10 years. We expect the situation to worsen despite factoring 54GW firm capacity addition as we estimate peak demand to grow by 138GW over FY23-32E.**
3. Based on the above, we **expect 'firm' capacity to command a premium over the next few years** until battery storage prices decline to a level which makes coal capacity redundant (USD89/kWhr by FY30E as per our global batteries team estimates). However, until then, PSP and untied coal & hydro capacities will likely earn returns significantly above their cost of equity.

How large is the opportunity?

1. We peg the **TAM for economics driven RE capacity addition at c.400GW**. This will also be in addition to our 203GW/48GW grid-level solar and wind capacity addition estimates between FY23-32E (vs. govt. target of 298GW/79GW).
2. Our India Stationary Storage Demand Supply model estimates the country's total

stationary utility-scale storage requirement at c.600GWhr by FY32E. **Even in the less likely scenario of a timely development of the entire c.400GWhr PSP capacity (under planning and development) and c.70GWhr BESS deployment, India will still see a 20% shortage of storage capacity.**

3. Realistically, we expect 19GW PSP and 18GW battery storage capacity installation by FY32E, with the balance demand being met by incremental coal capacity addition.
4. **We see potential upside of 23GW / 30GW coal capacity addition between FY24-32E, over and above the government's / GS estimate of 48GW / 42GW respectively, in our scenario to avoid peak shortages** after factoring the storage demand supply equation. We factor in limited execution on National Electricity Plan's forecast of outsized battery storage deployment (47GW by FY32E), on concerns around timely cost parity and domestic capacity adequacy.

Who stands to gain?

1. **PSUs (Public Sector Undertakings) with a significant funding cost advantage**, which will allow them to deploy large RE capacities while making materially better returns in RTC PPAs.
2. **Players with access to low cost PSPs** (owned or leased), allowing them to charge a premium for their ability to despatch firm on-demand renewable power.
3. **Developers with firm (coal & hydro) untied capacities** will potentially gain from pricing arbitrage arising out of a demand supply mismatch.
4. Lastly, **developers who will be able to add de-risked (cost plus) fossil capacities** to meet marginal demand growth while staying protected from the risk of stranded investments.

What can go wrong?

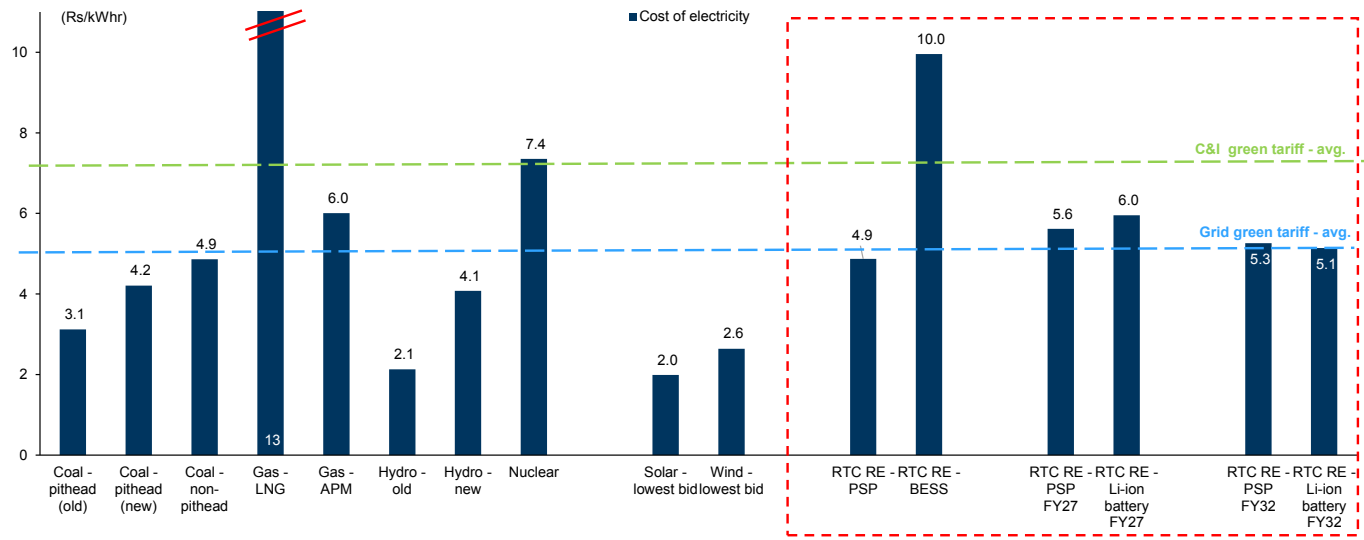
Underwhelming demand growth, as was the case in the last cycle post FY08, which led to major over capacity in the system. However, unlike last time, we draw comfort from: a) income growth led improving appliance penetration, b) increased importance of ensuring supply reliability now that electricity access is almost universal, c) sharp government focus on increasing electrification (railways, EVs, cooking etc.), and 4) support from the start of a manufacturing led economic upcycle.

What can surprise us?

1. Battery storage achieving cost parity and supply adequacy, faster than expected
2. Quicker and larger than anticipated PSP capacity execution

Thesis in 15 charts

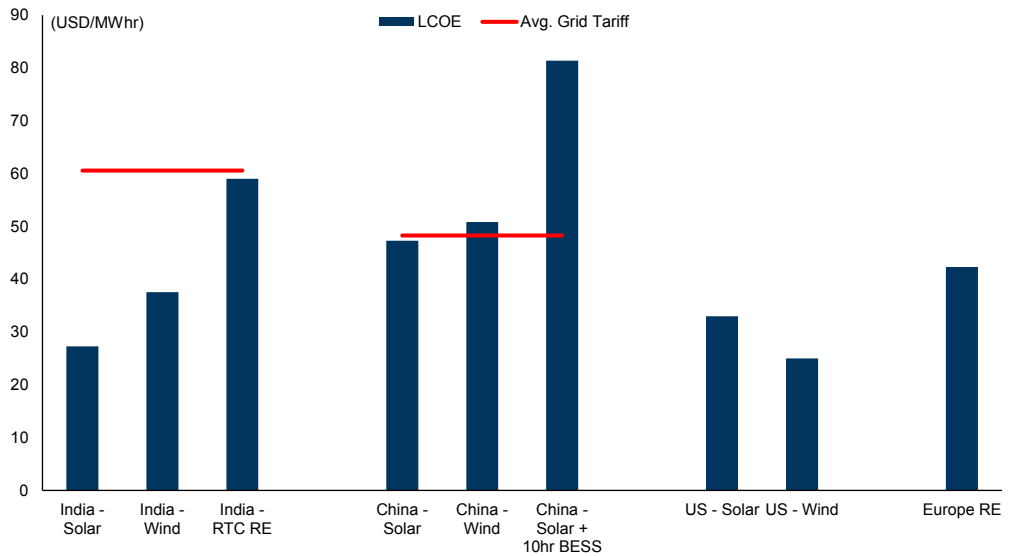
Exhibit 1: Round-the-clock renewable power already economically viable for corporate & industrial consumers viz-a-viz. grid tariff...



*LNG - Liquefied Natural Gas, APM - Adjusted Price Mechanism, BESS - Battery Storage, PSP - Pumped Hydro Storage, RTC RE - Round-the-Clock Renewables; as of Jun 23

Source: SERCs, CEA, Goldman Sachs Global Investment Research

Exhibit 2: ...with India having lowest RTC RE LCOE among major countries...

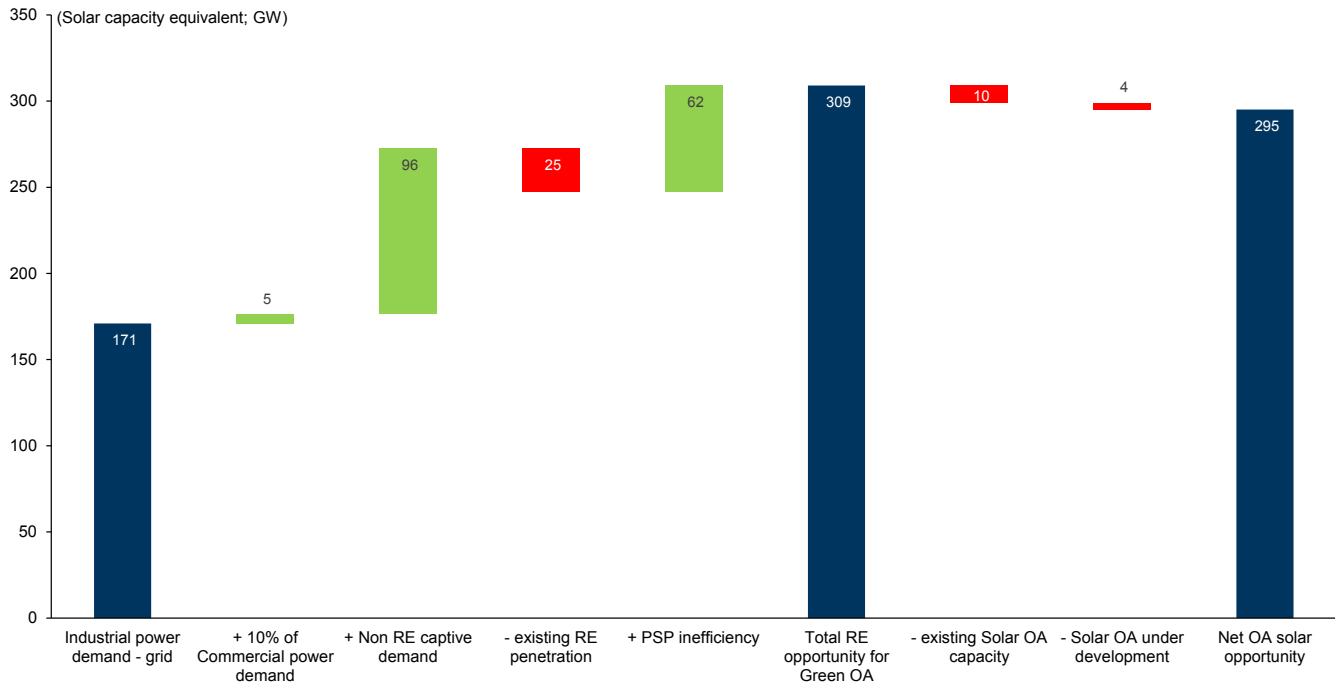


*LCOE - Levelised Cost of Energy as of Jun23

Source: Goldman Sachs Global Investment Research

Exhibit 3: ...which potentially opens c.300GW solar capacity addition opportunity, incremental to government targets

Our TAM analysis estimates solar capacity installation required to replace India’s entire non-RE industrial power consumption with green power

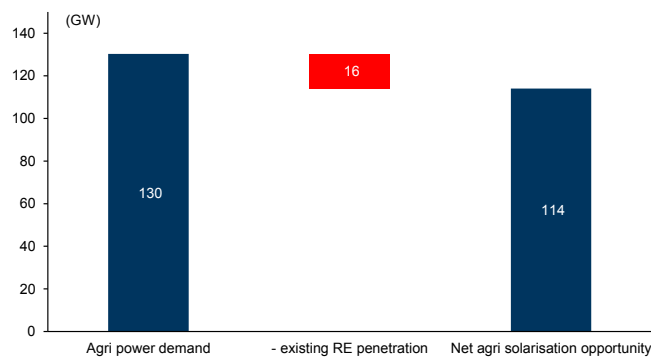


*OA - Open Access

Source: CEA, Goldman Sachs Global Investment Research

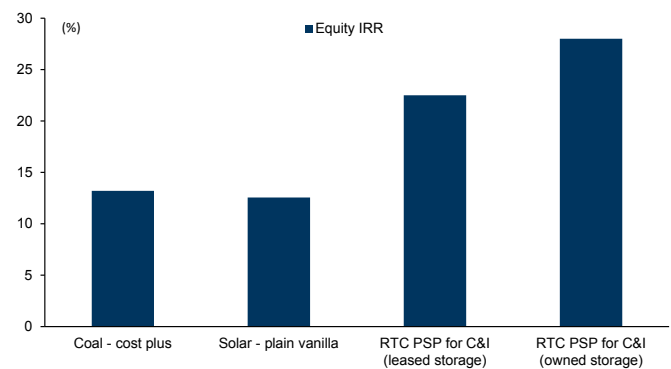
Exhibit 4: Similarly, solarisation of agricultural power supply is an economically viable use-case for 114GW solar capacity addition

Our TAM analysis estimates solar capacity installation required to replace India’s entire non-RE agricultural power consumption with green power



Source: CEA, Goldman Sachs Global Investment Research

Exhibit 5: We estimate materially better returns for pumped storage backed RTC-RE power vs. cost plus coal and plain vanilla solar...



*C&I - Commercial and Industrial as of Jun 23

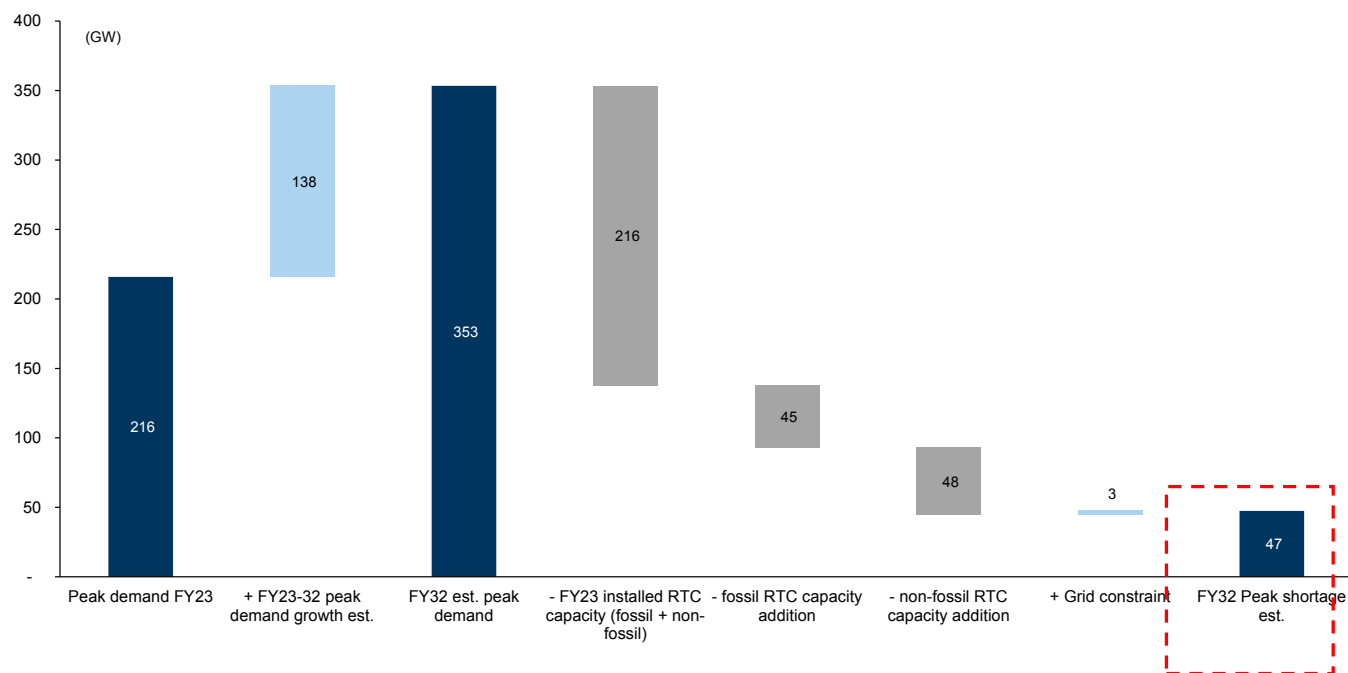
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 6: ...which along with a shift in customer profile (from B2G to B2B) can help upgrade 'traditional utilities' to 'transition enablers', driving valuation re-rating

Business model	Traditional Utility	Transition Enabler
Capacity type	Cost plus thermal, nuclear, hydro	Plain vanilla RE, RTC-RE, Power Storage
Offtaker	Licensed entities (state & pvt. DISCOMs)	DISCOMs & Corporates
Returns - equity IRR (%)	13-15%	12.5-25% - depending upon PPA complexity
Capital structure (D:E) - %	70:30	Typically 80:20 with scope for future capital recycling
Depreciation	Linked to capital repayment	Linked to asset life
Tariff design	2 part tariff with bulk of capital cost loaded upfront	Single part levelised tariff
Offtake agreement duration	25 years	12-25 years
Regulatory oversight	High; 5yr regulatory period	Low; mostly pertains to interpretation of agreement & regulations
Key risks	Unfavorable regulatory orders & return reset	Offtaker's credit worthiness, capex & opex overruns, refinancing risk
Valuation	Price / Regulated Book	DCF, peer multiples in high M&A environment

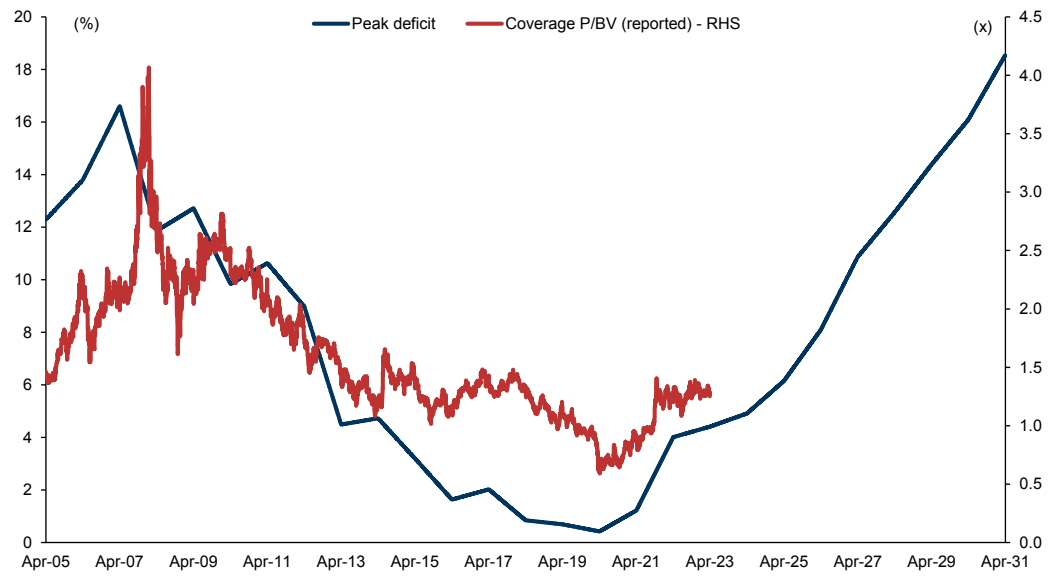
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 7: However, rising peak deficit will impact grid supply reliability - our India Peak Power Demand Supply model forecasts 47GW peak shortages by FY32E, factoring firm capacities planned & under-execution



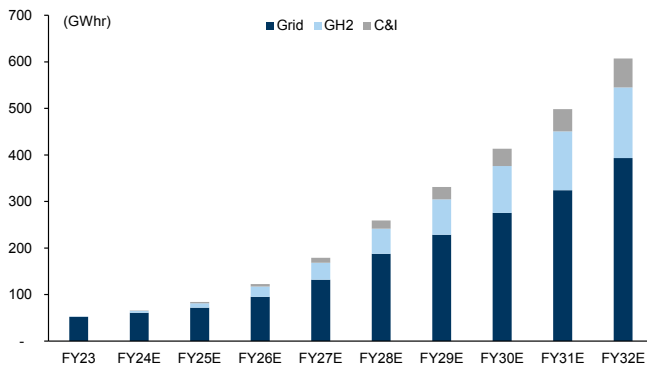
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 8: ...which could in-turn drive a sector rerating, as seen in the last cycle



Source: Datastream, Company data, Goldman Sachs Global Investment Research

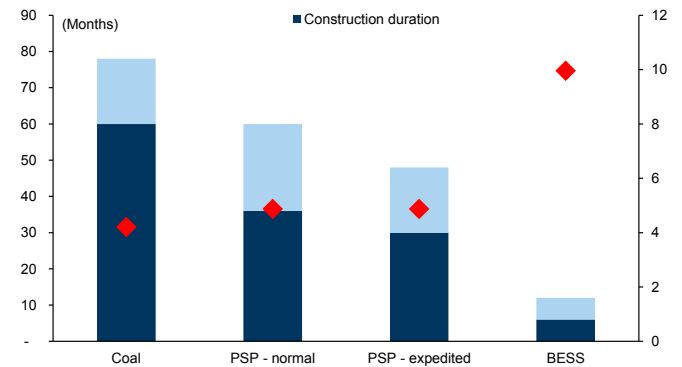
Exhibit 9: Our India Stationary Storage Demand Model factors estimated grid shortages along with demand from Green Hydrogen and Corporate Decarbonisation use-cases



*GH2 - Green Hydrogen

Source: CEA, Goldman Sachs Global Investment Research

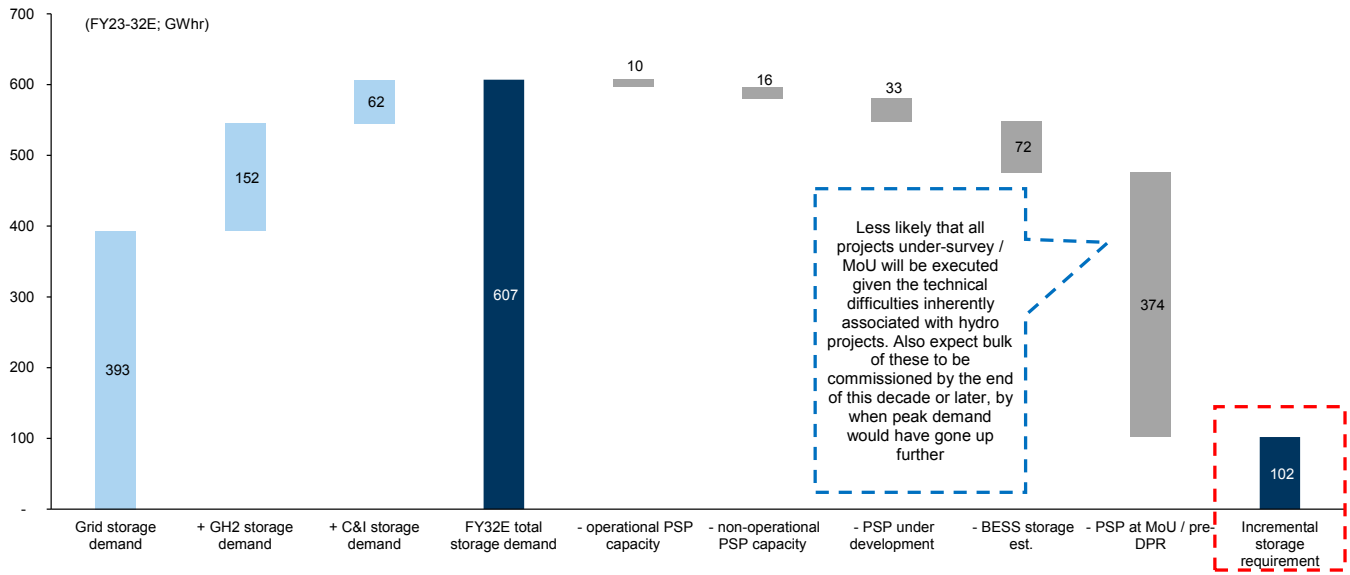
Exhibit 10: While battery storage takes the least time to deploy, its levelised cost is 2x that of pumped hydro, which has a long execution timeline even after fast-tracking approvals



*battery and pumped-hydro levelised cost factors 2 cycles of operation per day

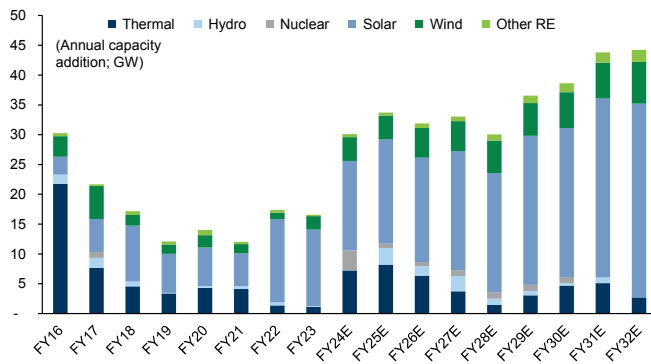
Source: CEA, Ministry of Power, Goldman Sachs Global Investment Research

Exhibit 11: ...and even in the unlikely scenario of all planned pumped hydro capacities being executed in time, India will run c.20% storage deficit by FY32E



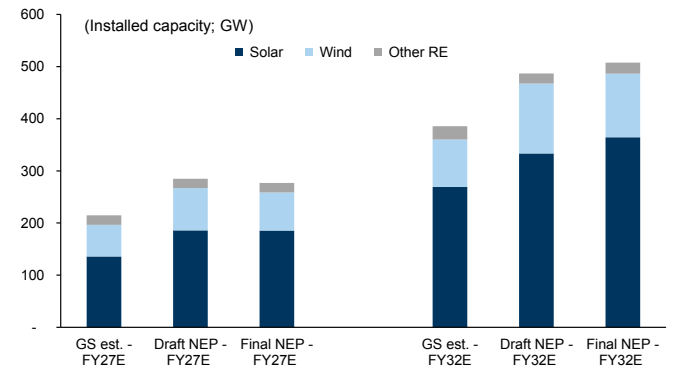
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 12: While we estimate solar to drive the bulk of grid capacity addition between FY23-32E...



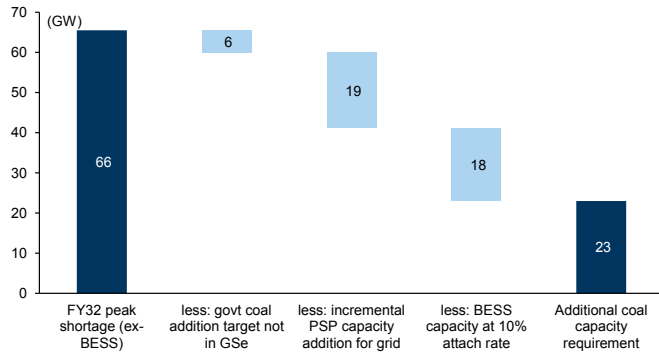
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 13: ...inadequacy of storage capacity will impact DISCOMs' appetite for infirm RE power, hence our grid RE capacity addition estimates are lower than government targets



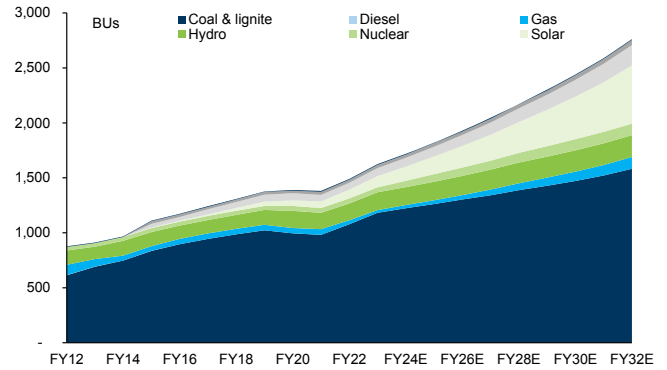
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 14: We estimate requirement of at least 23GW coal capacity addition incremental to government targets (30GW beyond our estimates) to avoid peak shortages, factoring the pumped hydro demand supply equation and our battery cost curve estimates



Source: Goldman Sachs Global Investment Research

Exhibit 15: India's generation mix likely to be coal dominated over the next decade even with significant planned RE capacity addition



Source: CEA, Goldman Sachs Global Investment Research

#1 India's economics driven RE transition different from that witnessed elsewhere globally

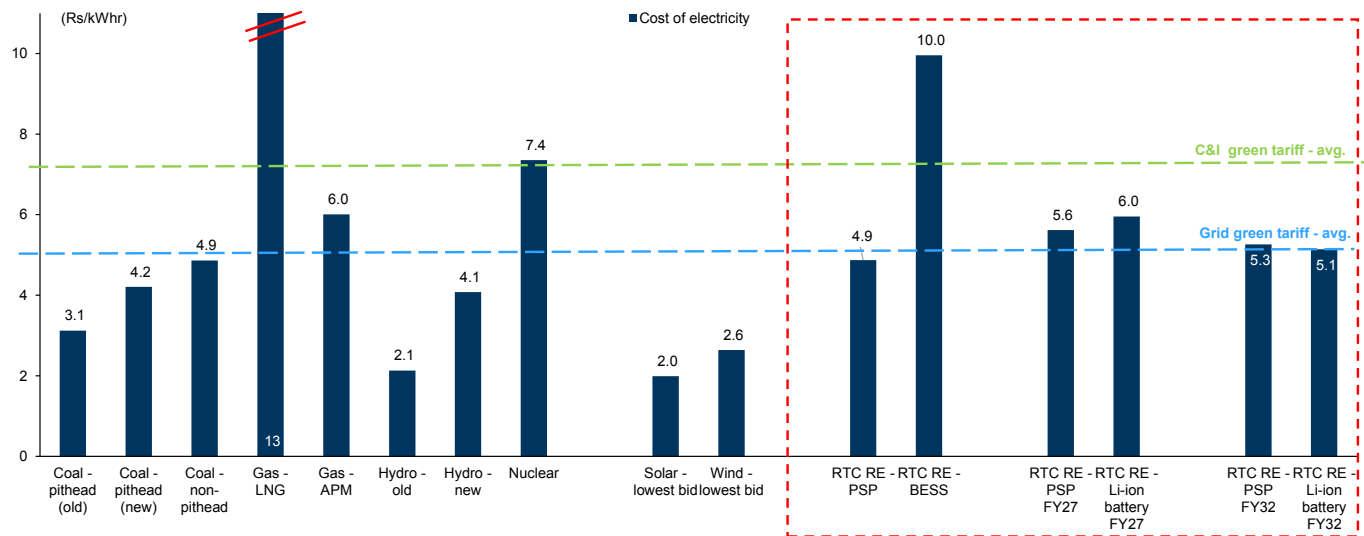
Viability of RTC RE opens c.300GW corporate RE transition market: Our calculations suggest pumped hydro backed RTC RE power is already cheaper than the average 'green tariffs' offered by DISCOMs to commercial and industrial consumers. This cost advantage, along with the corporate push for achieving net 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.

While the Central Government has notified 'Green Open Access Norms' which have eased processes and pre-conditions to facilitate direct RE procurement by corporates, we note the historical resistance by state government owned DISCOMs to letting go of their most profitable customers as evidenced by the imposition of incremental costs such as cross-subsidy surcharge (CSS), additional surcharge etc. by state electricity regulators to reduce the attractiveness of open access vis-a-vis grid tariffs.

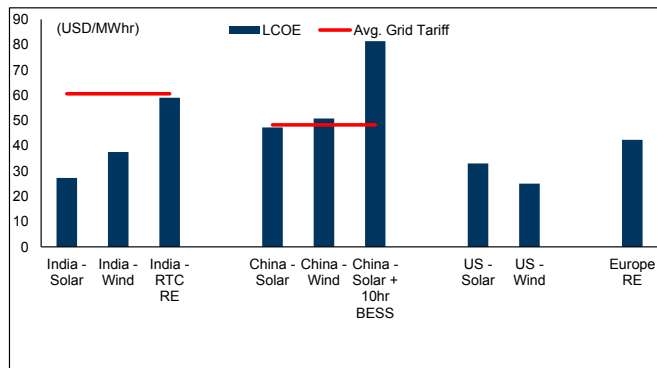
Exhibit 16: Round-the-clock Renewables backed by pumped storage already at cost parity with non-pithead coal



*LNG - Liquefied Natural Gas, APM - Adjusted Price Mechanism, BESS - Battery Storage, PSP - Pumped Hydro Storage, RTC RE - Round-the-Clock Renewables; as of Jun 23

Source: Goldman Sachs Global Investment Research

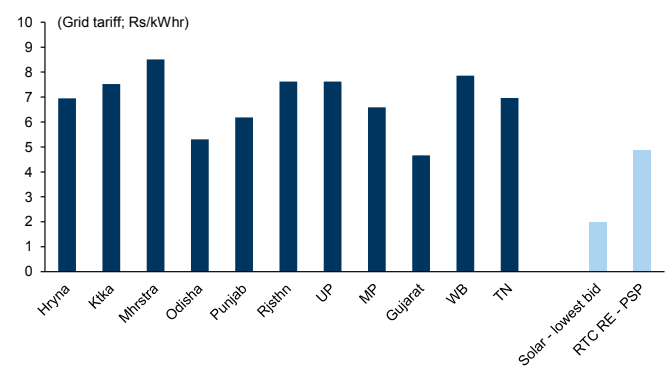
Exhibit 17: India's RTC RE LCOE lowest among among major countries



*LCOE - Levelised Cost of Energy, as of Jun 23

Source: Goldman Sachs Global Investment Research

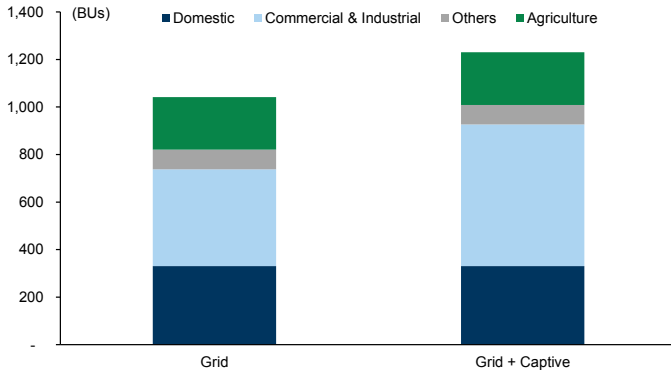
Exhibit 18: C&I tariff charged by DISCOMs across most states significantly higher than RTC RE power cost



as of CY22

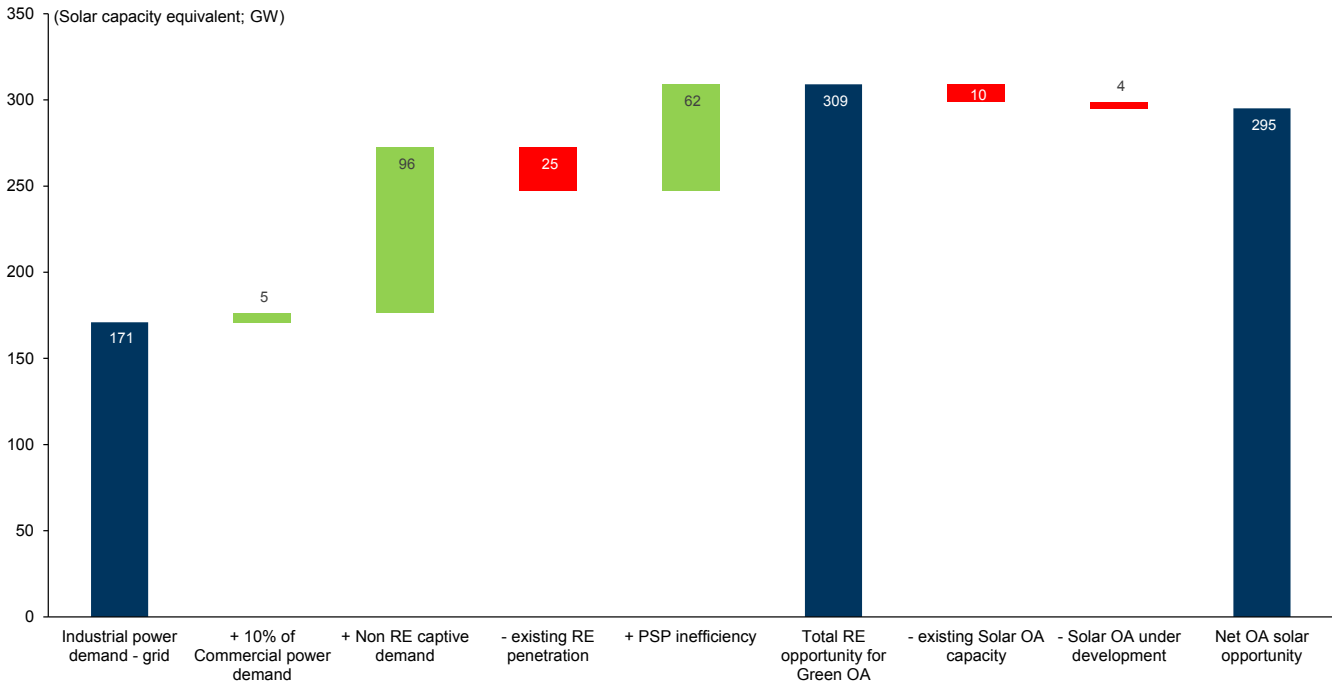
Source: SERCs, SECI, Goldman Sachs Global Investment Research

Exhibit 19: Commercial & Industrial sectors account for c.50% of India's overall, c.40% of grid power consumption
FY21 power consumption breakup



Source: CEA, Goldman Sachs Global Investment Research

Exhibit 20: c.300GW solar capacity equivalent opportunity from Corporate & Industrial decarbonisation



*OA - Open Access

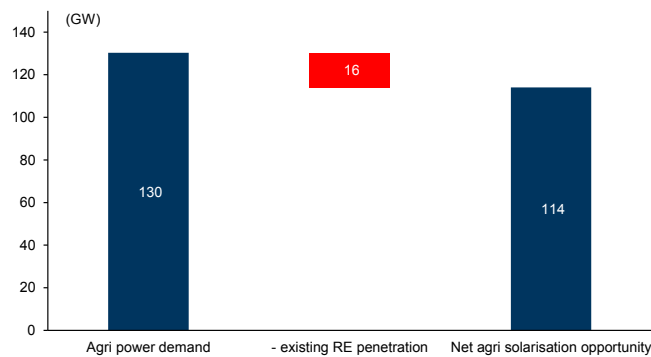
Source: CEA, Goldman Sachs Global Investment Research

Solarisation of agricultural power supply low hanging fruit for financially

struggling DISCOMs: Similarly, solarisation of agriculture is an economically viable use case for India’s RE transition, and helps to cut the subsidy and loss burden of DISCOMs. We attribute c.70% of DISCOMs’ losses & subsidies (Rs1.7tn in FY22) to agricultural power supply cost under-recovery.

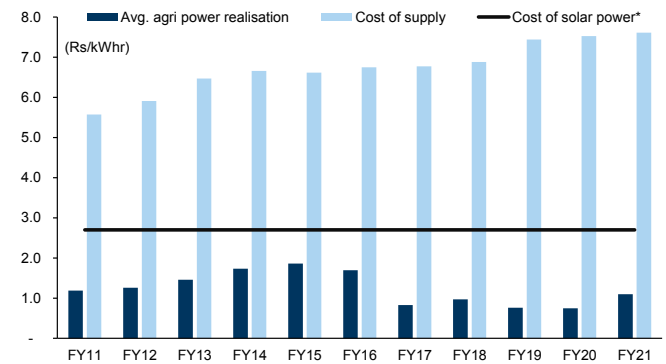
In our opinion, solarisation of the agricultural power supply is low hanging fruit since the load profile will support infirm (but inexpensive) solar capacity addition without the requirement of corresponding storage capacity addition for grid balancing. We estimate 114GW solar equivalent capacity opportunity from full solarisation of the agricultural power supply, which could help save c.35-46% in subsidy outgo for state governments, thereby supporting a material improvement in the financial condition of DISCOMs.

Exhibit 21: 114GW capacity addition opportunity from solarisation of agriculture



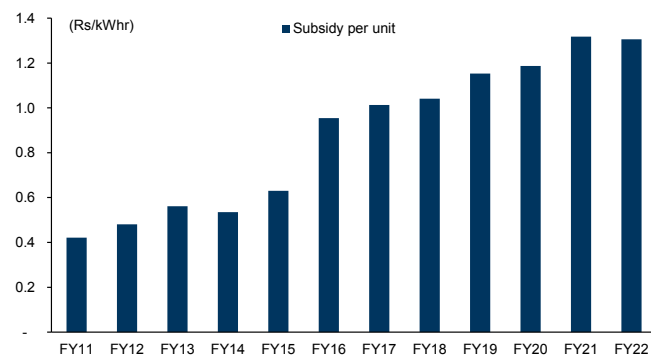
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 22: Agricultural power realisation significantly below cost of power supply - indicating high level of cross-subsidisation
* incl. state transmission charge



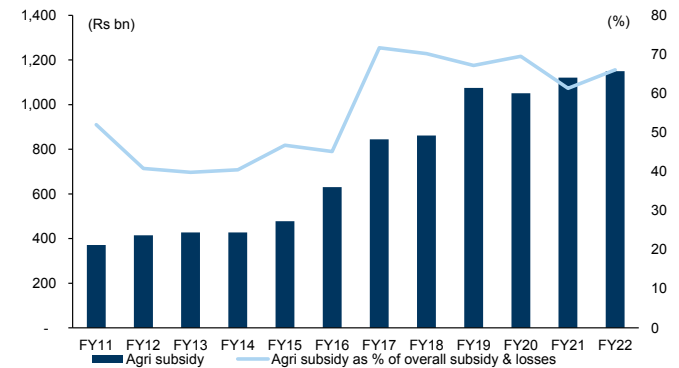
Source: PFC, Goldman Sachs Global Investment Research

Exhibit 23: Subsidy contribution per unit of power supplied has risen at 11% CAGR since FY11



Source: PFC, Goldman Sachs Global Investment Research

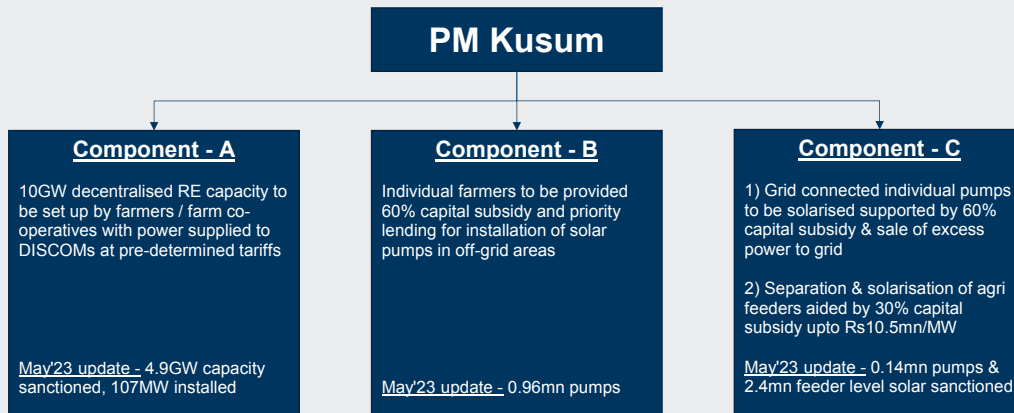
Exhibit 24: We estimate agri supply cost under-recovery to contribute c.70% of DISCOM subsidies and losses



Source: PFC, Goldman Sachs Global Investment Research

Case study 1: PM Kusum Scheme - what it entails & the progress so far

Exhibit 25: Central Government's PM Kusum scheme provides capital subsidy support for solarisation of agricultural power consumption; however, execution is yet to pick up



Source: Ministry of New & Renewable Energy, Goldman Sachs Global Investment Research

Case study 2: Learnings from Andhra Pradesh's (AP) agri solarisation drive

- In Feb'20, AP government announced plans to set up 10GW solar capacity for supplying 9 hours of free power to farmers for irrigation. In FY21, the state had to allocate a subsidy worth Rs84bn towards supply of 13bkWhr free electricity to the agri segment.
- In Jan'23, AP government entered an agreement with Solar Energy Corporation of India (SECI) for procurement of 7GW solar power at a tariff of Rs2.49/kWhr. This capacity will be operationalised between Sep'24-Sep'26 in phases and will ease the subsidy burden by c.Rs25bn.

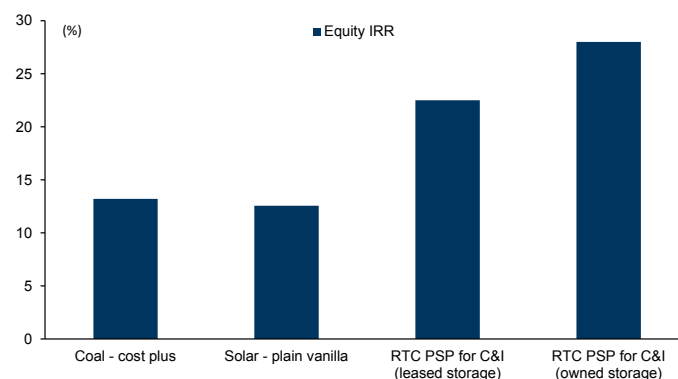
400GW economically viable RE capacity addition opportunity over and above government targets and GSe: The earlier mentioned ~400GW 'economically viable' opportunity is over and above the government's and our grid RE capacity addition targets and could see an accelerated uptake given adoption in both these cases is driven by economic pull rather than government push. Our RE capacity estimates do not factor these since corporate RE projects will likely operate as 'group captives' and we are yet to see a meaningful uptick in solarisation of agri. feeders. In the event of an accelerated pick up in solar capacity installation for agri. power supply, our RE capacity addition numbers could see an upward revision.

#2 ...with the potential to disrupt 'Utility' business model, for the better

Superior returns from corporate RE transition opportunity....: As per our estimates, the corporate RE transition opportunity offers materially superior returns to developers over plain vanilla solar or cost plus coal power supply to DISCOMs. We attribute higher returns to the following factors:

1. High cost of grid power supply to industrial and commercial consumers on account of cross-subsidisation by DISCOMs makes switch to RTC RE an economically viable decision. We estimate RTC RE power cost to be 35% lower vs. grid green tariff for corporate consumers connected to the central grid, and on average 10% lower for those connected to state grids.
2. Rising pressure on corporates to meet their net zero commitments is also driving a demand side push for green open access. While state DISCOMs have begun offering a separate 'green' tariff, the coal dominated nature of India's grid power supply mix and requirement for traceability of supply chains make green open-access more attractive.
3. Dependence on the grid also exposes consumers to grid supply reliability issues, especially in a phase of rising peak shortages. Rather than incurring an additional cost of maintaining a back up (which would mostly be polluting diesel gensets), corporates will likely find dedicated RTC RE supply reassuring.
4. Lastly, given the importance of power storage (in overcoming the inherently intermittent nature of RE power) and its inadequate capacity, corporates seem willing to pay a premium for firm, despatchable renewable power, especially for running processes which require constant electricity supply.

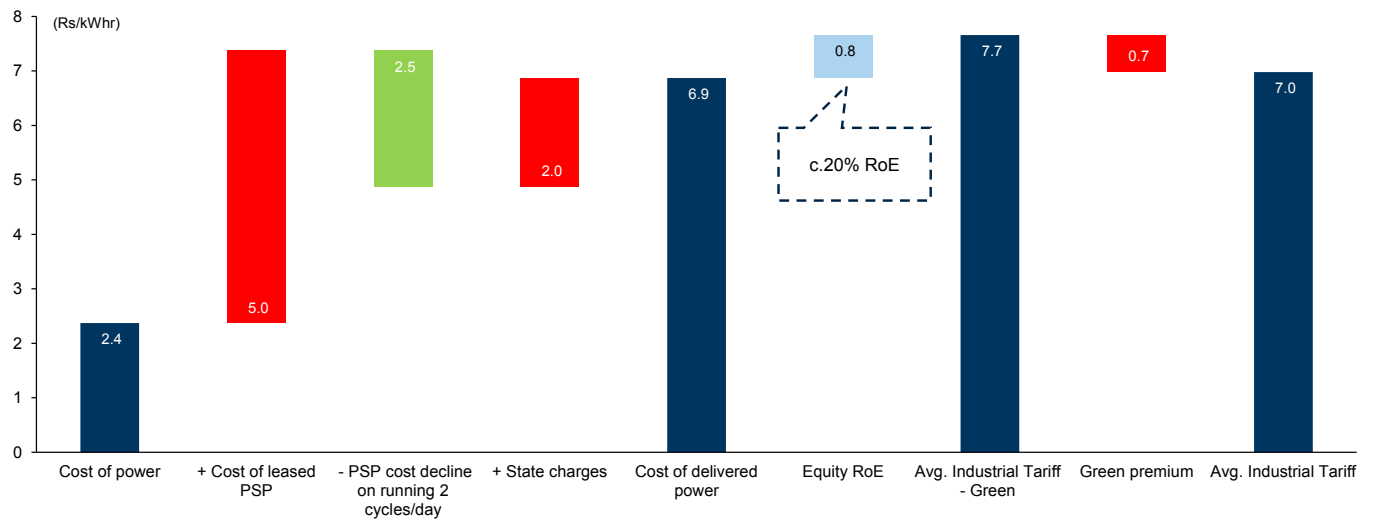
Exhibit 26: Estimate pumped hydro backed RTC power to generate significantly better equity IRRs than plain vanilla solar & regulated coal capacities at average green C&I tariff



as of Jun 23

Source: Goldman Sachs Global Investment Research

Exhibit 27: RTC-RE RoE waterfall for C&I business opportunity

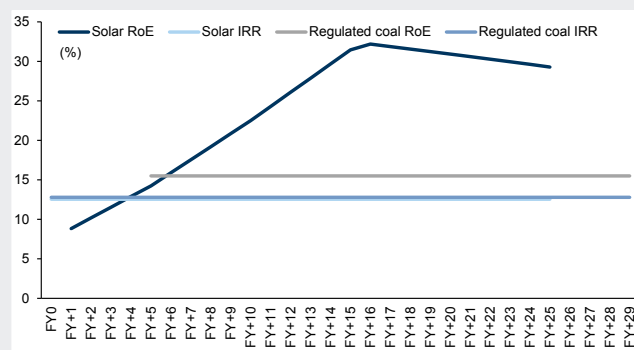


Source: Goldman Sachs Global Investment Research

Why IRR is a better metric to assess RE investments vs. RoE?

Unlike the flat RoE trendline of traditional regulated coal power plants (which operate on a cost plus basis), the tariff structure of renewable projects set up under auction & bilateral mechanisms entail rising RoE over time as project debt is repaid. Additionally, the shorter execution timeline of RE projects allows lower capital downtime when equity investment doesn't earn any returns. While RE projects might appear to have lower RoE vs. regulated thermal plants, this metric doesn't capture the benefit of their shorter execution timeline and inherent tariff design.

Exhibit 28: Shorter execution period, back-ended RoE increase on debt repayment ensures similar equity IRR for plain-vanilla solar asset vs. higher RoE regulated coal plants



Source: Goldman Sachs Global Investment Research

...has the potential to upgrade 'Utility' business model: Along with better returns, the corporate RE transition will also improve the quality of counterparty for developers as they shift from being Business-to-Government (B2G) suppliers to Business-to-Business (B2B) service providers. We foresee corporate RE demand will drive a structural upgrade in business model of developers from 'Utilities' to 'Transition Enablers', providing energy-as-a-service, and potentially driving a sector re-rating. Additionally, the opportunity size which we have estimated factors only the RE capacity required for shifting from existing grey to green power supply. With a heightened focus on increasing the share of RE electricity in the primary energy mix, there could be further upside to our estimates.

Exhibit 29: Head to Head: Transition Enablers present superior returns opportunity than Traditional Utilities, albeit at a higher risk

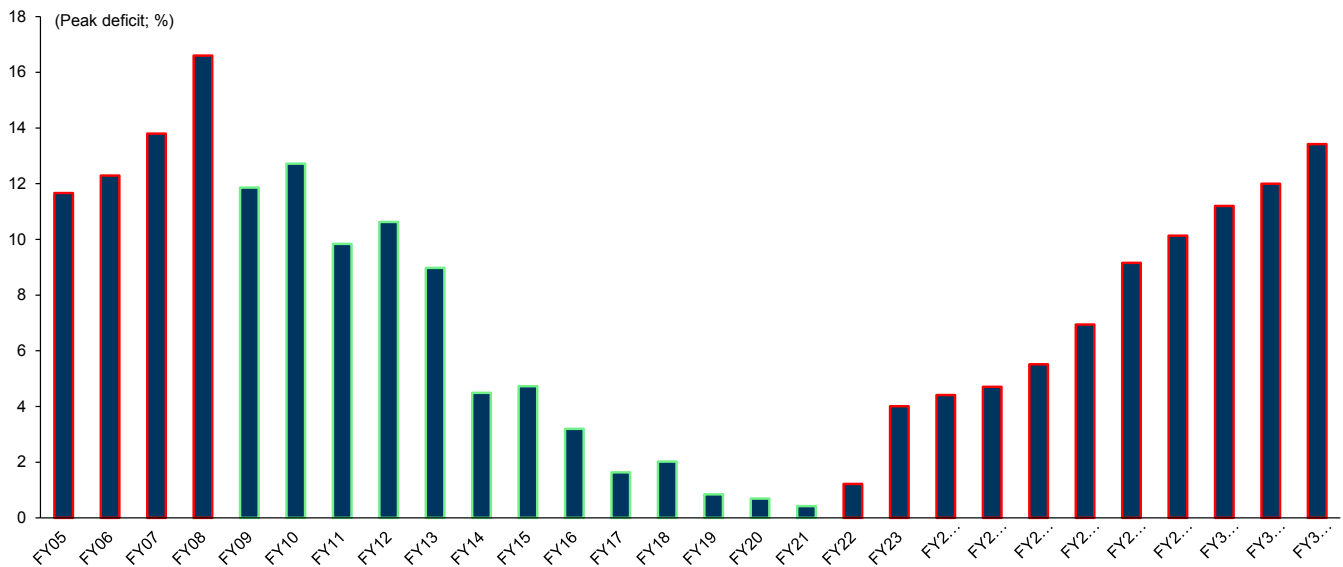
Business model	Traditional Utility	Transition Enabler
Capacity type	Cost plus thermal, nuclear, hydro	Plain vanilla RE, RTC-RE, Power Storage
Offtaker	Licensed entities (state & pvt. DISCOMs)	DISCOMs & Corporates
Returns - equity IRR (%)	13-15%	12.5-25% - depending upon PPA complexity
Capital structure (D:E) - %	70:30	Typically 80:20 with scope for future capital recycling
Depreciation	Linked to capital repayment	Linked to asset life
Tariff design	2 part tariff with bulk of capital cost loaded upfront	Single part levellised tariff
Offtake agreement duration	25 years	12-25 years
Regulatory oversight	High; 5yr regulatory period	Low; mostly pertains to interpretation of agreement & regulations
Key risks	Unfavorable regulatory orders & return reset	Offtaker's credit worthiness, capex & opex overruns, refinancing risk
Valuation	Price / Regulated Book	DCF, peer multiples in high M&A environment

Source: Regulatory Commissions, Ministry of Power, Goldman Sachs Global Investment Research

#3 But rising peak deficits will risk supply reliability...

Transition could be threatened by shortages: Our India Peak Demand Supply model forecasts that the phase of peak shortages has already begun and is expected to worsen in the medium term. We believe this mismatch will challenge the country’s energy security, and will be prioritised over RE transition. We estimate c.47GW peak shortages by FY32E based on our peak demand and capacity addition estimates. While our demand estimates are lower than that of the government (which has been revising its estimates upwards), we think the government’s battery capacity addition target of 47GW by FY32E is on the higher side. Our model does not factor PSP capacity not under execution yet.

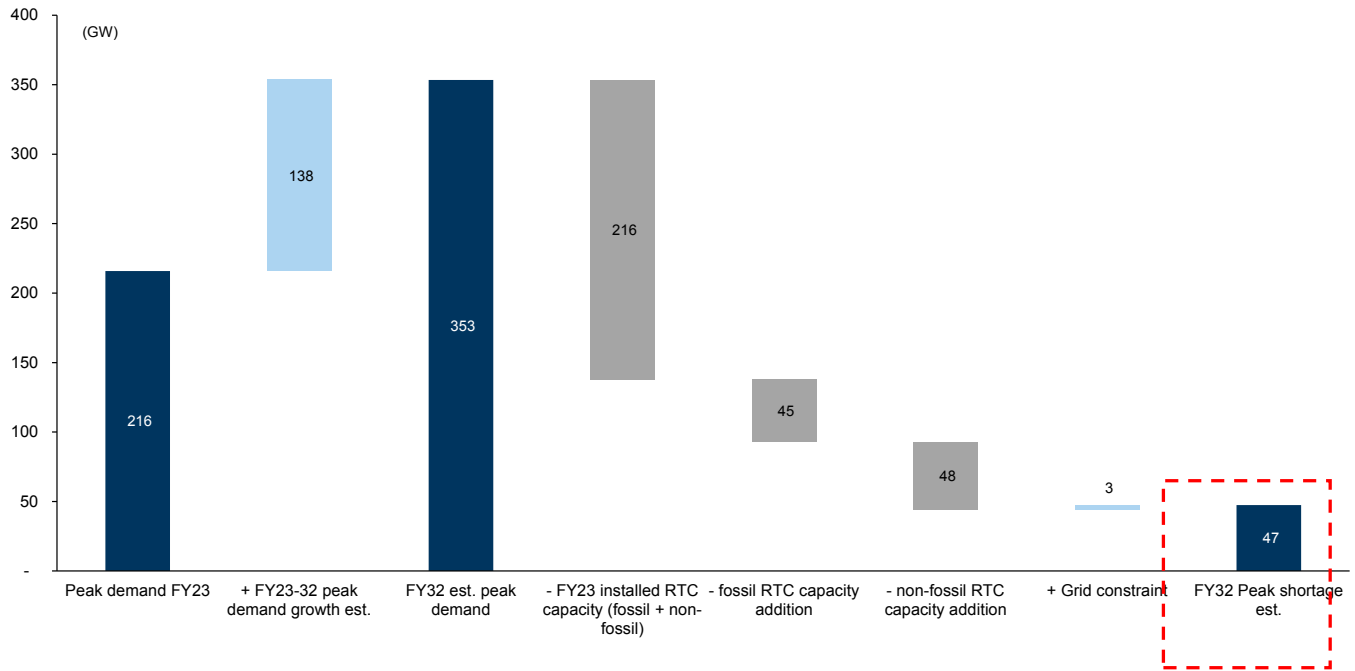
Exhibit 30: Our proprietary India Peak Demand Supply model indicates the beginning of a multi-year supply deficit situation...



*red borders denote period of rising peak deficits, green denote period of declining peak deficits

Source: CEA, Goldman Sachs Global Investment Research

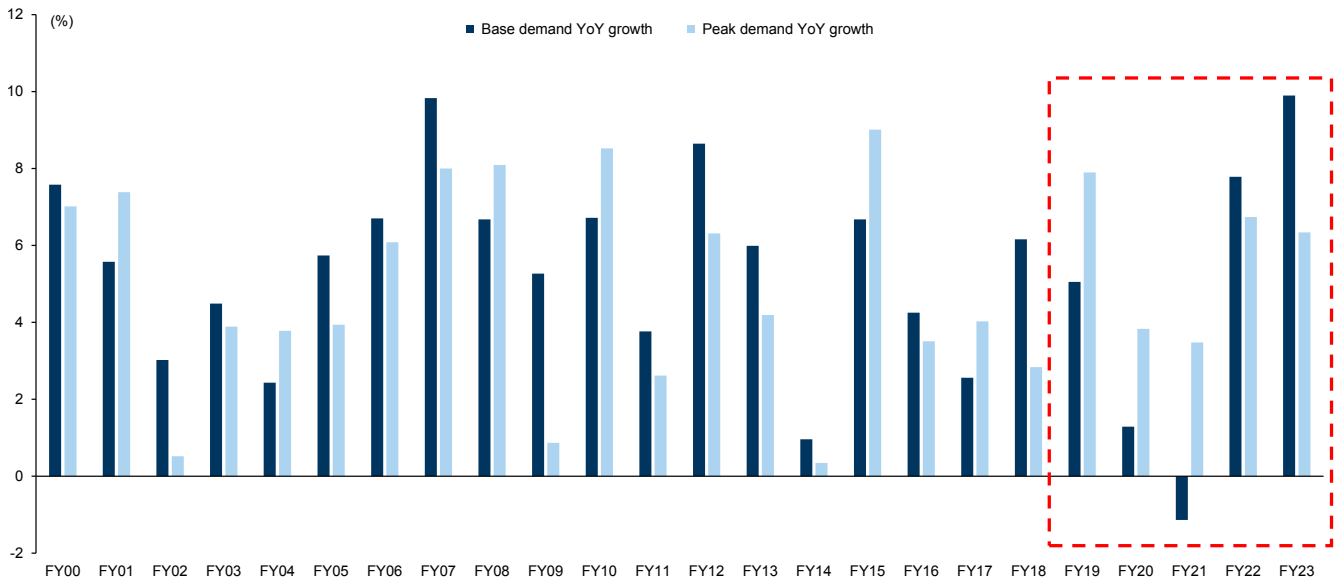
Exhibit 31: ...with 47GW peak shortages estimated by FY32E, based on current capacity addition pipeline



Source: CEA, Goldman Sachs Global Investment Research

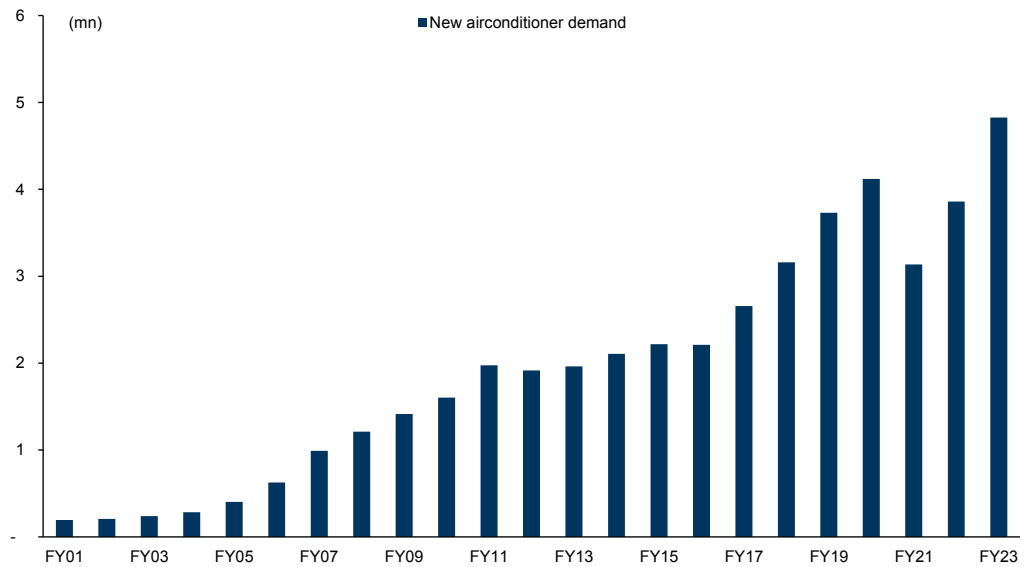
Peak demand surge structural: Backed by the 100% household electrification scheme under SAUBHAGYA and rising appliance penetration (air conditioning and refrigeration primarily), we believe the recent out performance of peak demand growth over base is indicative of a structural shift. We expect this trend to continue, if not accelerate, as appliance penetration and usage duration grows in tandem with the improvement in disposable income of households.

Exhibit 32: Peak demand growth has outpaced base demand by 115bps FY18 onwards vs. 65bps underperformance b/w FY00-FY18



Source: CEA, Goldman Sach Global Investment Research

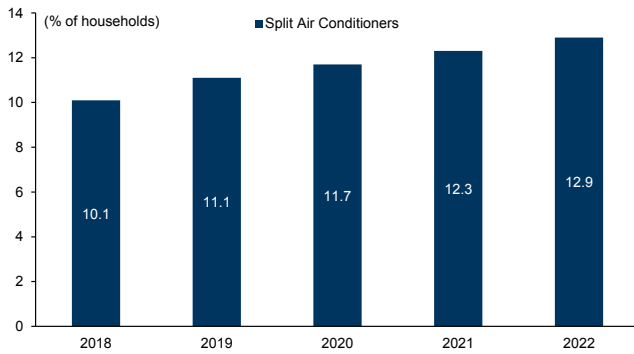
Exhibit 33: New airconditioner demand has risen at c.16% CAGR between FY01-23



*new airconditioner sales = total sales - replacement sales

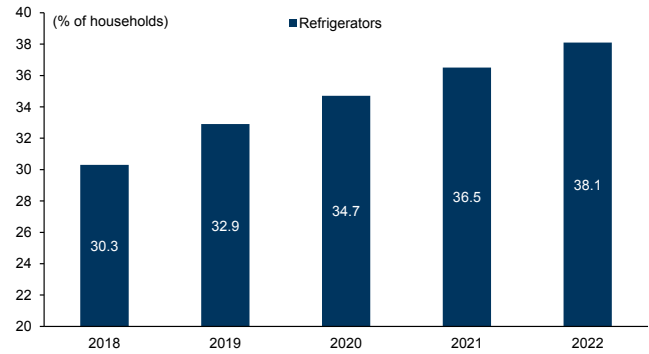
Source: Company Data, Goldman Sachs Global Investment Research

Exhibit 34: Penetration of split airconditioners has increased c.300bps over the last 5 years...



Source: Euromonitor, Goldman Sachs Global Investment Research

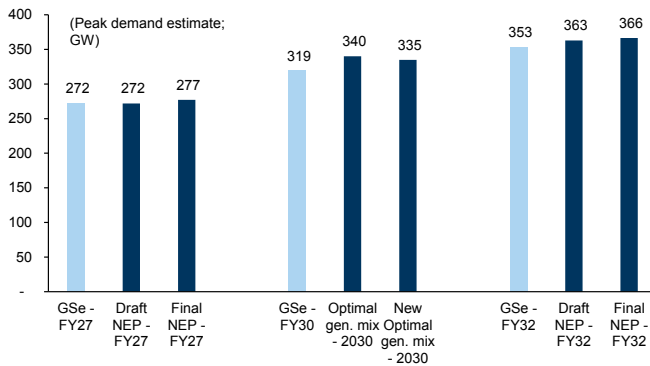
Exhibit 35: ...and that of refrigerators by c.800bps over the same period



Source: Euromonitor, Goldman Sachs Global Investment Research

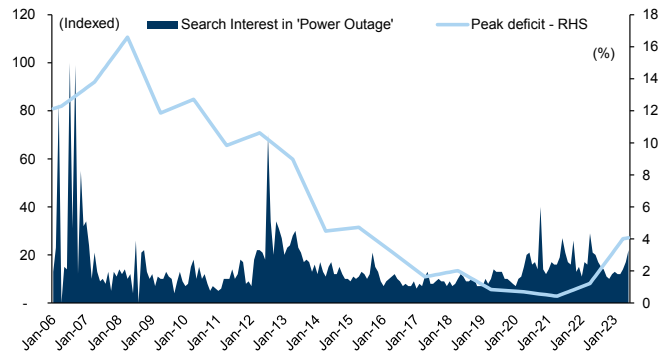
GS peak demand estimates below rising government estimates: Our peak demand estimates are conservatively lower than those of the government. However, upward revision in government estimates for both FY27E and FY32E are indicative of an uptick in demand momentum and could lead to an upside surprise on our estimates.

Exhibit 36: Our peak demand estimates below those of the government, indicating possibility of larger than expected shortages...



Source: CEA, Goldman Sachs Global Investment Research

Exhibit 37: ...which is corroborated by rising search interest in power outages despite relatively clement weather in CY23 summers



Source: Google Trends, Goldman Sachs Global Investment Research

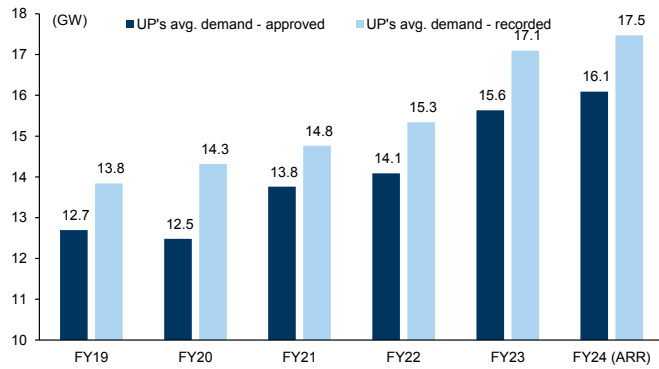
UP Regulator’s recent analysis of peak demand supply equation indicative of system-wide situation: Uttar Pradesh’s power regulator (UPERC), in a suo-motu order on a long-term power procurement plan by state DISCOMs over FY28-40E flagged the emergence of widening peak shortages at the state level from FY23 onwards. The order, a volte-face from its FY19 order which highlighted peak supply adequacy till FY26-27E, cited sharper than expected increase in peak demand along with lower than planned firm capacity addition as the reasons behind the deficit.

Based on its demand projection and planned capacity addition, UPERC pegged state’s peak shortage at 26GW in FY32E (c.40% of our all India peak shortage estimate) and 63GW by FY40E.

Interestingly, the regulator also highlighted the mismatch between solar supply hours and the state’s load profile, rendering the standalone solar capacity addition largely

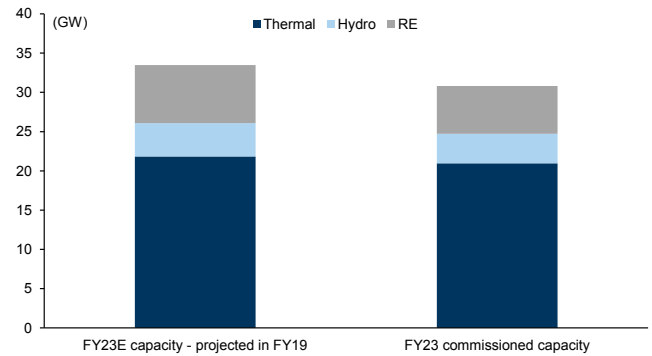
incapable of meeting evening peak loads and allowing DISCOMs to enter into long term power purchase agreements with firm supply sources.

Exhibit 38: UP's actual average power demand has consistently been higher than state regulator's estimates...



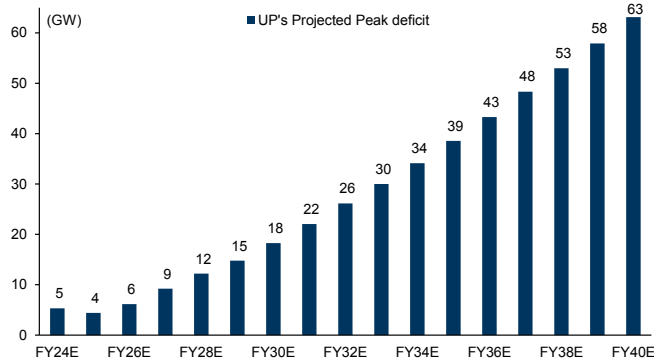
Source: UPERC, Goldman Sachs Global Investment Research

Exhibit 39: ...while actual capacity addition has lagged projections by 8%



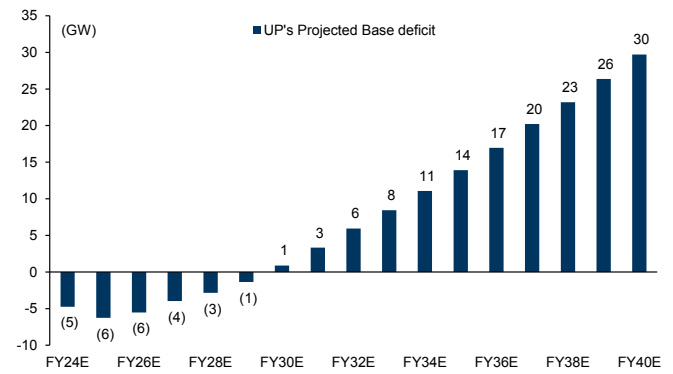
Source: UPERC, Goldman Sachs Global Investment Research

Exhibit 40: UP Electricity Regulator projects 63GW peak deficit by FY40E in the state without adequate firm capacity tie-up



Source: UPERC, Goldman Sachs Global Investment Research

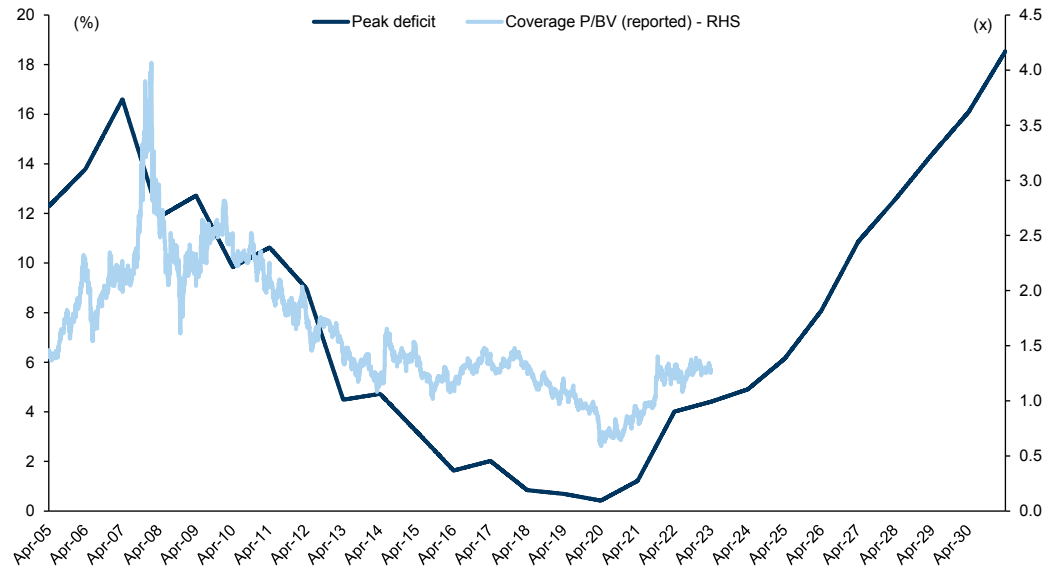
Exhibit 41: ...and base deficit of 30GW



Source: UPERC, Goldman Sachs Global Investment Research

Coverage valuations closely track peak demand supply situation: While developers with open capacities tend to be the earliest and largest beneficiaries of power shortages, our coverage valuations have closely tracked the peak demand supply situation historically despite having mostly tied up capacities. We attribute this to an upward revision in the street’s capacity growth expectation, especially in the legacy coal power business which has been impacted by ESG pressures of late.

Exhibit 42: Upcoming peak shortages could drive up sector valuations



Source: Datastream, CEA, Goldman Sachs Global Investment Research

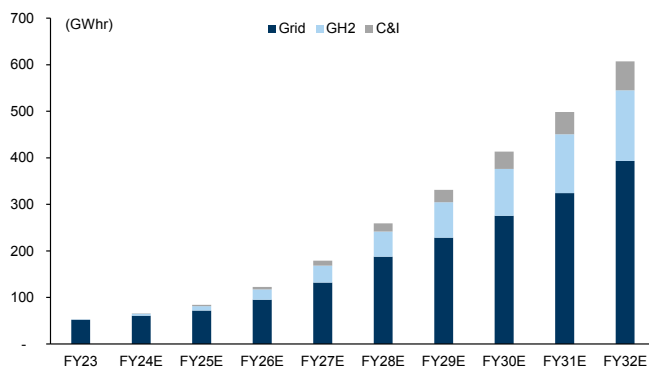
#4 ...even as Pumped Hydro emerges as India's rescuer, ad interim

Estimating c.600GWhr India storage demand by FY32E with pumped hydro storage most preferred:

Our India Stationary Storage Demand model estimates storage capacity requirement of 607GWhr by FY32E, c.50% higher than the government estimate as it factors the projected peak deficit along with demand from corporate decarbonisation and green hydrogen projects.

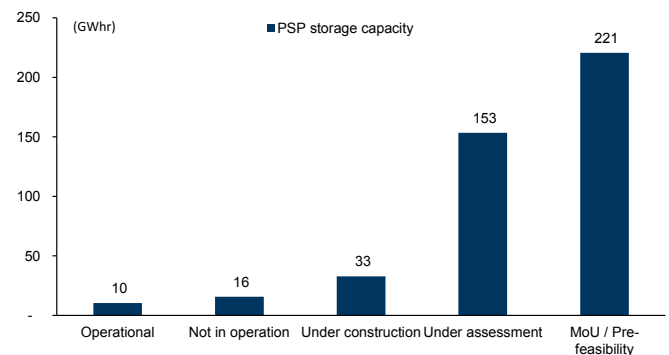
We expect the bulk of this storage demand to be met by PSPs, as they ensure energy security and facilitate the RE transition at costs significantly below that of battery storage, with negligible import dependence and have limited environmental impact. We estimate PSP backed RTC RE power to cost only 15-17% more than new pithead coal plants (negligible after factoring the transmission cost waiver), with the difference expected to narrow over time as coal and coal logistics costs rise.

Exhibit 43: Our India Stationary Storage Demand Model factors estimated grid shortages along with demand from Green Hydrogen and Corporate Decarbonisation use-cases



Source: CEA, Goldman Sachs Global Investment Research

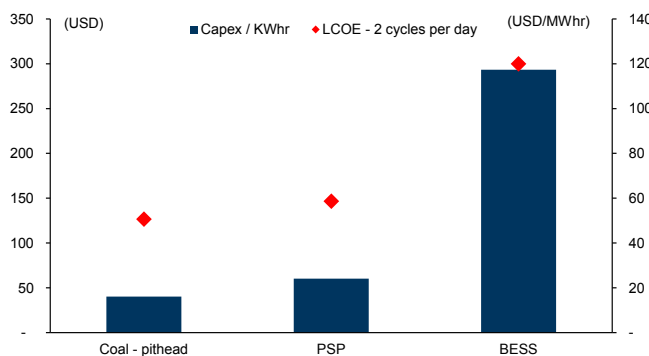
Exhibit 44: Less than half of installed PSP capacity operational as storage due to technical & legal issues; bulk of capacity addition 5-10 years away



as of Jun 23

Source: CEA, Goldman Sachs Global Investment Research

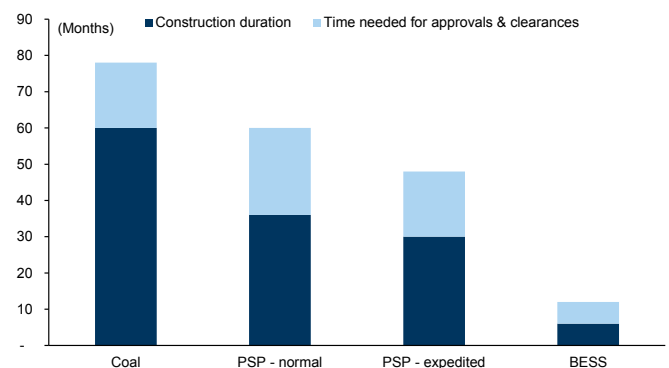
Exhibit 45: Pithead coal still the cheapest dispatchable power source on both capex & opex basis but pumped hydro catching up



as of Jun 23

Source: CEA, Goldman Sachs Global Investment Research

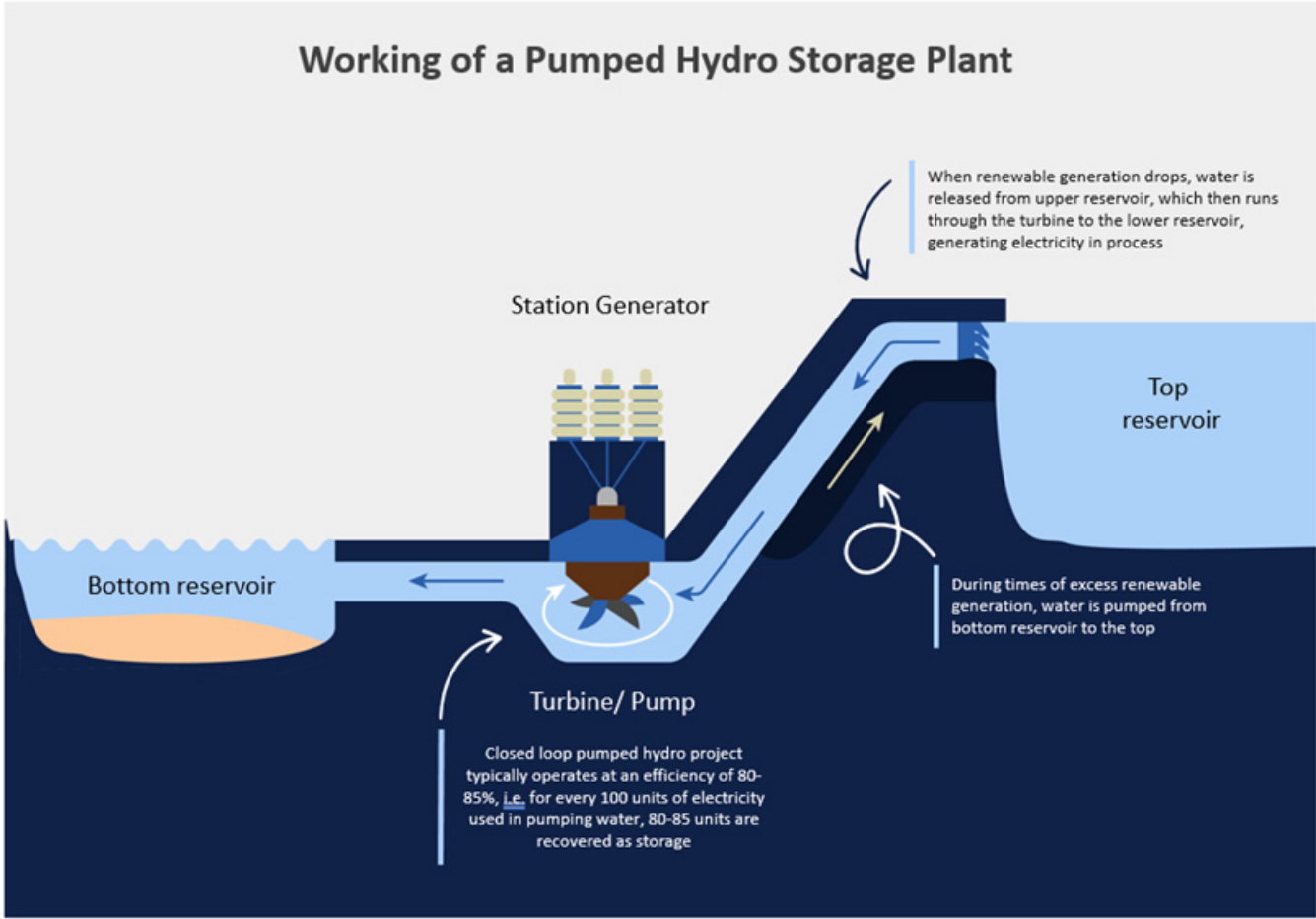
Exhibit 46: Battery storage quickest to deploy; government trying to bring down pumped-hydro execution time by easing approval process



as of Jun 23

Source: CEA, Goldman Sachs Global Investment Research

Exhibit 47: Pumped Hydro Storage - key to overcoming RE intermittency



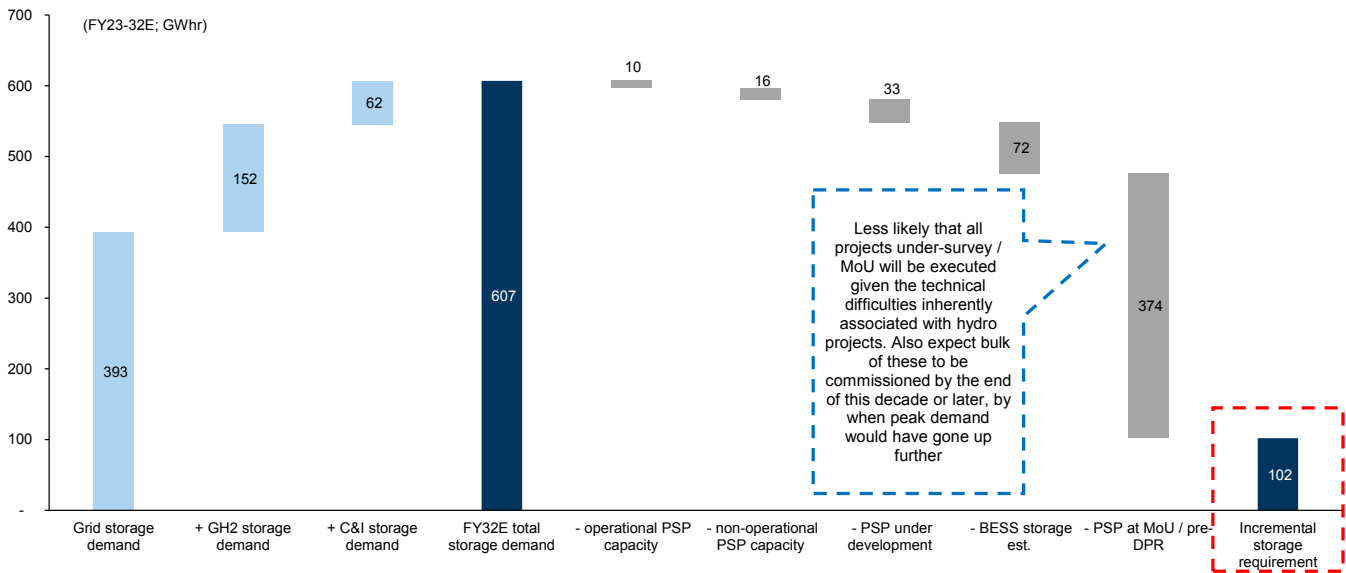
Source: Goldman Sachs Global Investment Research

#5 Battery storage’s cost disparity could force higher coal capacity addition

c.20% storage capacity shortage expected even in optimistic PSP execution scenario:

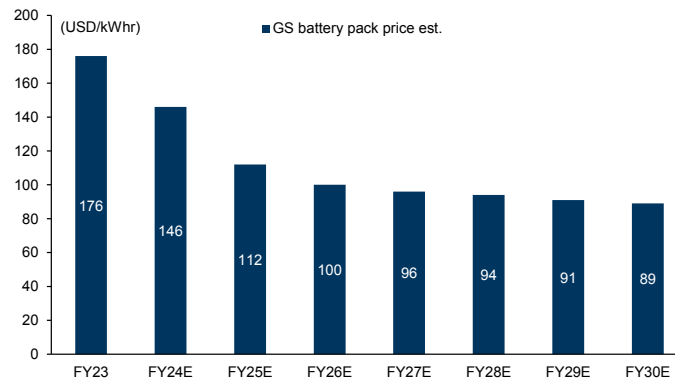
Even in the unlikely scenario of all PSPs currently under MoU, survey, investigation etc. becoming operational by FY32E, India will likely face a c.20% shortage in meeting its storage requirement. While government estimates factor outsized battery storage (BESS) capacity deployment (47GW/236GWhr) to bridge this gap, we find it unlikely to happen based on GS battery cost curve forecast.

Exhibit 48: Significant capacity ramp up required to meet our estimate of c.600GWhr storage demand by FY32E



Source: CEA, Goldman Sachs Global Investment Research

Exhibit 49: Our Global Batteries team expects battery pack price to decline at c.9% annually between FY23-30E, making it competitive against pumped hydro storage only by the end of this decade

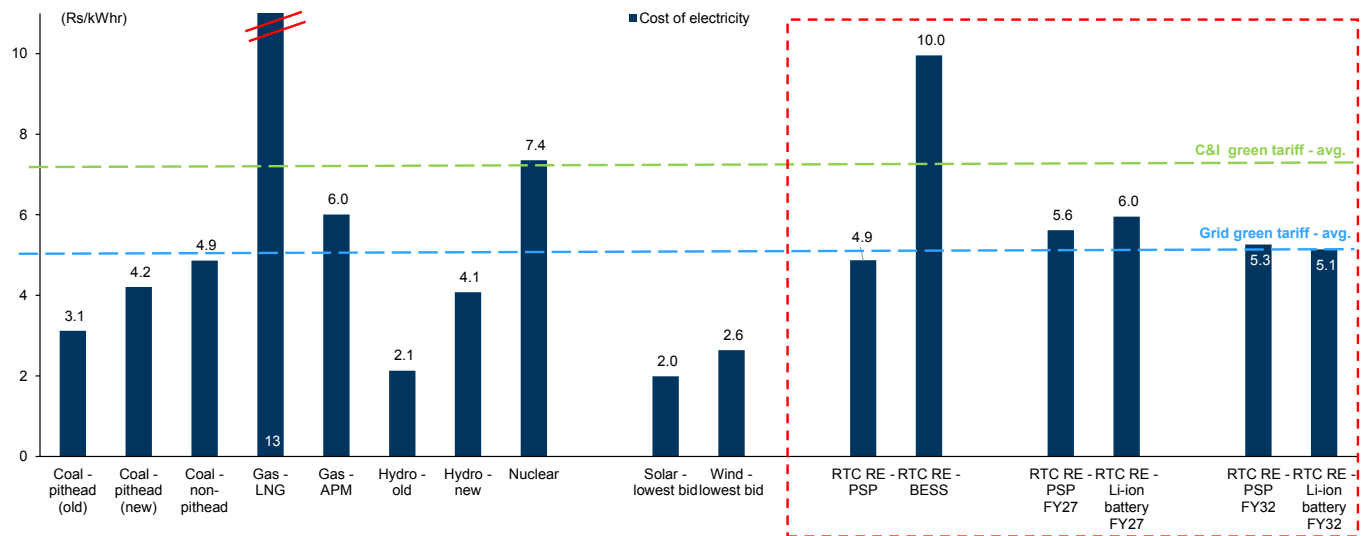


Source: Goldman Sachs Global Investment Research

We forecast BESS backed RTC RE to achieve cost parity with PSP backed RTC RE only by FY31-32E, post which its accelerated deployment can be expected. Further, the

government’s central transmission capex plan for accommodating 500GW RE capacity by 2030 envisages a c.24% battery storage attachment rate on 180GW RE capacity requiring new transmission infra - 2x that of GSe for China (avg. basis) by the same time.

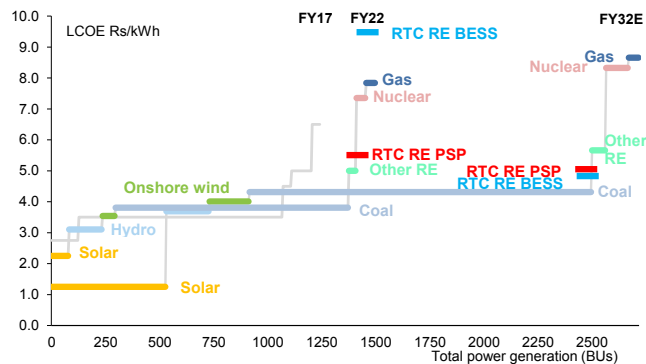
Exhibit 50: Battery backed RTC RE expected to achieve cost parity vs. PSP backed RTC RE only by FY32E



*LNG - Liquefied Natural Gas, APM - Adjusted Price Mechanism, BESS - Battery Storage, PSP - Pumped Hydro Storage, RTC RE - Round-the-Clock Renewables; as of Jun 23

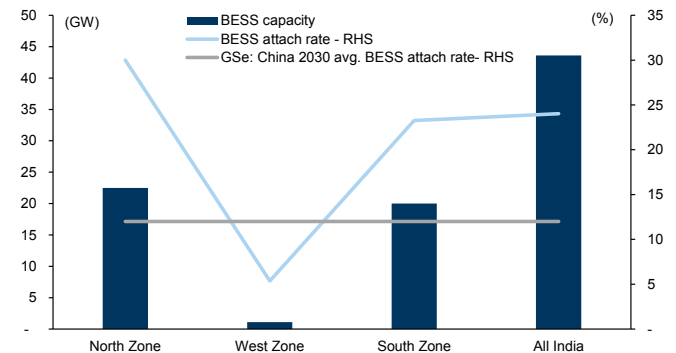
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 51: RE is expected to flatten the average power cost curve over time but managing peaks will become costlier



Source: CEA, Goldman Sachs Global Investment Research

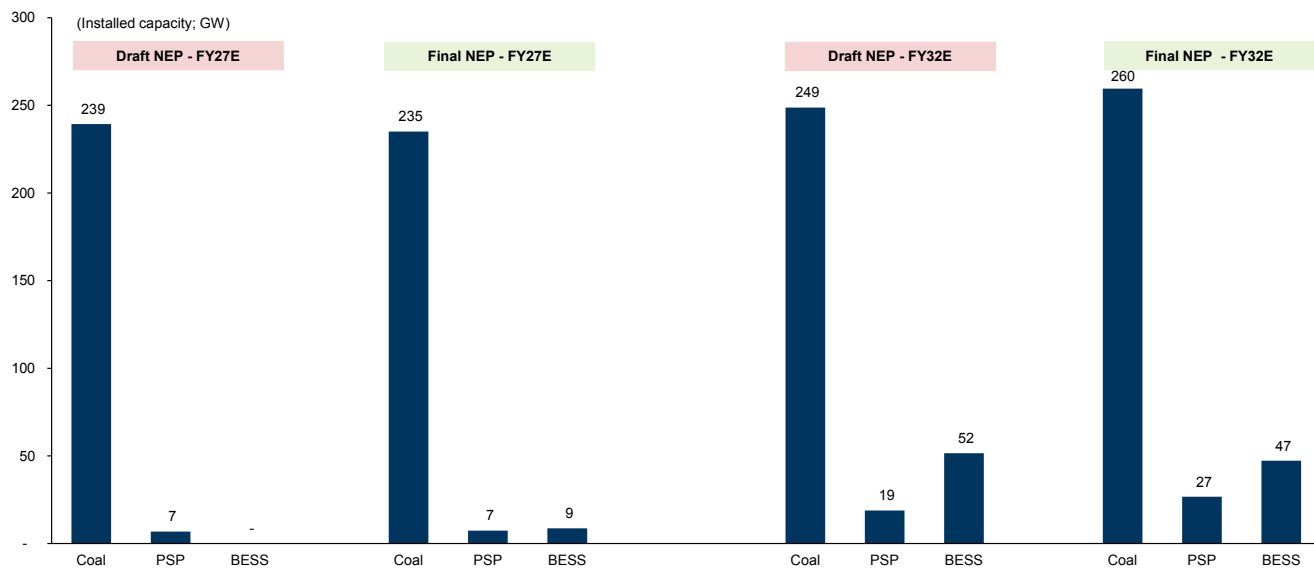
Exhibit 52: Government’s 2030 transmission plan envisages 24% battery attachment rate - 2x that of GSe for China



Source: CEA, Goldman Sachs Global Investment Research

Increasing government coal capacity targets corroborates our thesis: The government has revised its FY32E coal capacity target upward by 11GW in the final National Electricity Plan document over the draft, along with an increase in planned PSP capacity while reducing battery storage targets. We view this move as a reinforcement of our thesis of higher than expected coal capacity addition to meet peak shortages as BESS deployment might overwhelm at its expected cost trajectory.

Exhibit 53: Increase in government’s FY32E coal and pumped storage capacity targets indicative of declining confidence on battery storage cost viability by then



Source: CEA, Goldman Sachs Global Investment Research

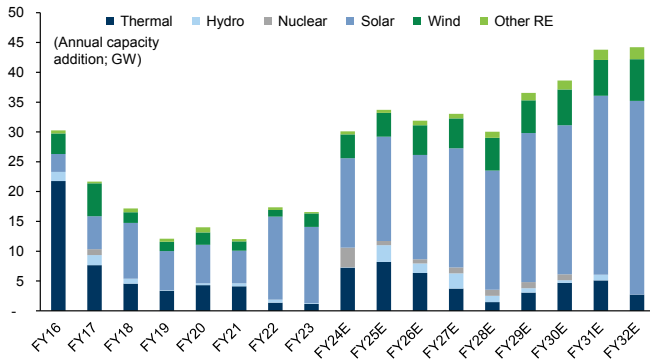
Exhibit 54: UP Electricity Regulator commenting on decision of setting up Battery storage vs. Thermal power plant in its order dated 09/07/2019

b. In case the economics justifies and when the battery prices fall below per MW cost of setting up a new TPP with evacuation system. Discoms may consider contracting some capacity from the battery storage- based power plants located near load centers to meet their short duration peak demand.

Source: UPERC

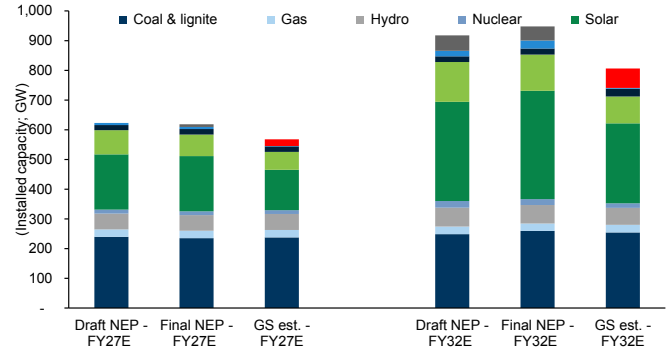
Building 320GW+ capacity addition over FY24-32E, with 80% of it coming from renewable sources (200GW+ solar, 48GW wind, 43GW coal, 10GW hydro and 9GW nuclear). However, our RE capacity estimates are 24% lower than government figures as we expect inadequate power storage capacity to limit DISCOMS’ appetite for infirm RE power. Our coal capacity addition estimate is also 6GW lower than that of the government, as we await planning and execution clarity. On the storage front, we factor pumped storage capacity of only c.3GW which is under construction or has received clearance to commence execution vs. the government’s target of 27GW and 18GW battery storage (10% attachment rate assumption FY25E-32E).

Exhibit 55: Estimating solar to drive bulk of capacity addition over the next 9 years...



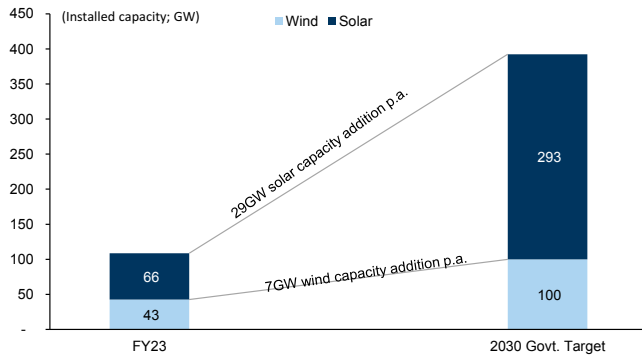
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 56: ...though we are below government targets



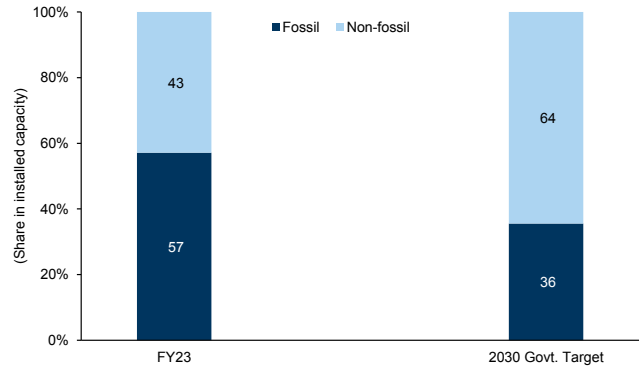
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 57: Government's 500GW clean capacity target by 2030E require 29GW solar & 7GW wind capacity addition annually...



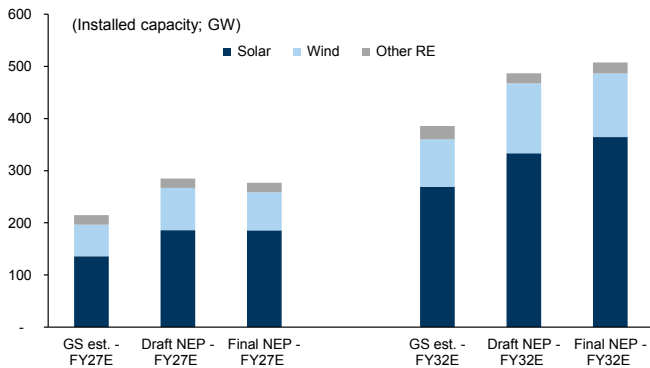
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 58: ...which will result in ~2/3rd of installed capacity being from non-fossil sources



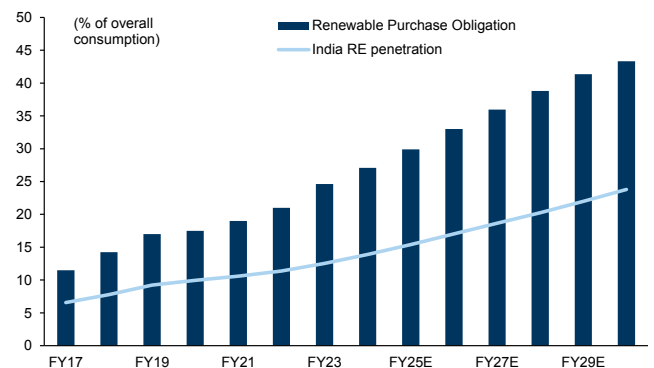
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 59: Our FY27E & FY32E RE capacity estimates are 22-24% below government targets as DISCOM demand for 'non-firm' RE capacity could overwhelm



Source: CEA, Goldman Sachs Global Investment Research

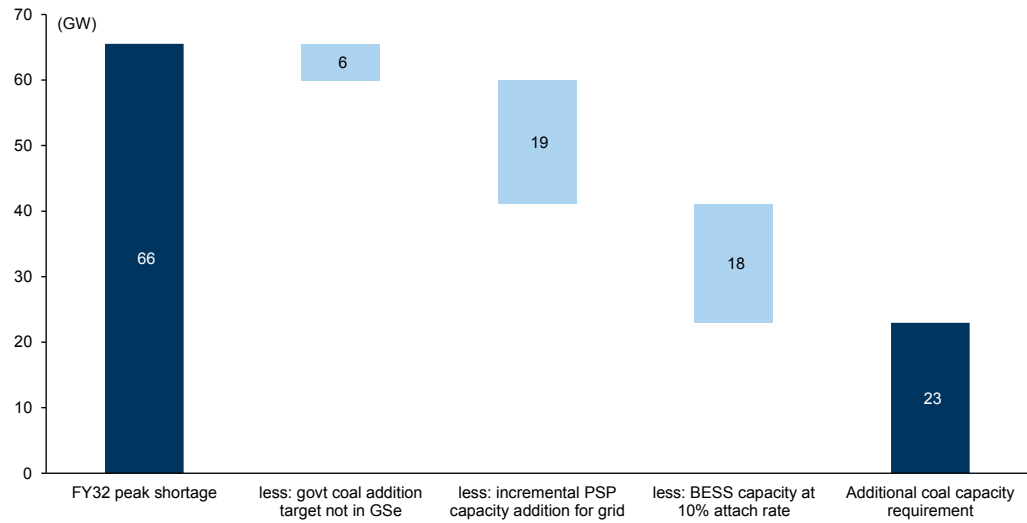
Exhibit 60: Government mandated Renewable Purchase Obligation (RPO) to cross 40% of overall consumption by FY30E but we estimate overall RE penetration to lag behind



Source: Ministry of Power, Goldman Sachs Global Investment Research

Estimating 23GW coal capacity addition above government targets: We estimate 23GW incremental coal capacity addition requirement above the government’s target of 48GW (30GW above GSe of 42GW) by FY32E, to meet peak shortages. Our estimates factor a lower BESS attachment rate of 10% vs. government’s plan of 24% on c.180GW RE capacity requiring transmission infra upgrade, considering the GS battery cost curve forecast. Also, our pumped hydro capacity addition estimate accounts for execution timelines and competing demand from corporate decarbonisation and green hydrogen projects. In our opinion, this incremental coal capacity needs to be ordered over the next 3-4 years for its timely completion to meet the projected peak shortages.

Exhibit 61: We estimate 23GW coal capacity addition requirement beyond government targets to avoid peak deficits by FY32E



*peak shortage number includes BESS capacity as well

Source: CEA, Goldman Sachs Global Investment Research

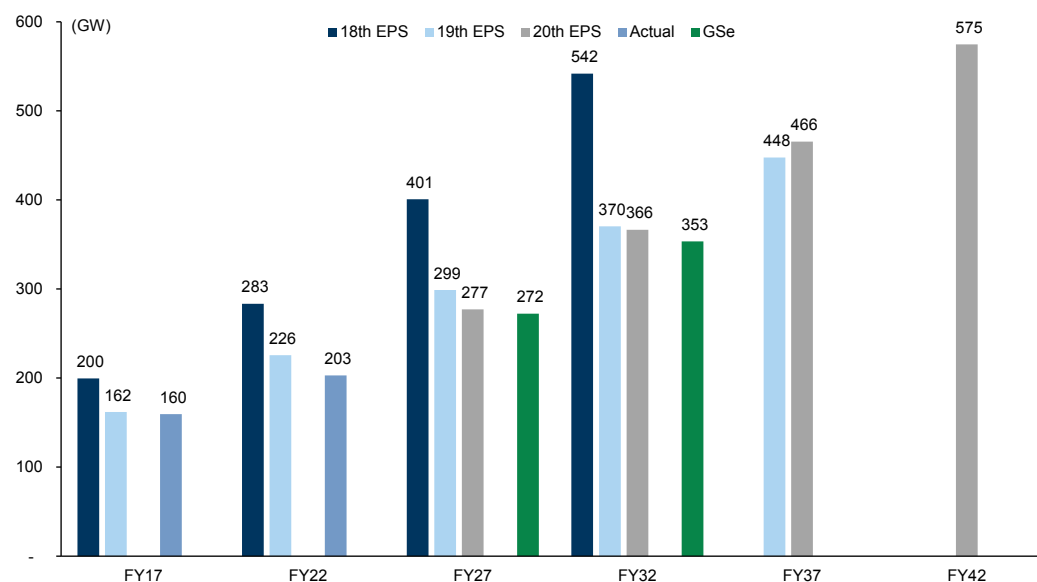
#6 Demand growth underperformance key risk to our thesis

We foresee demand growth underperformance as the largest risk to our thesis, given the repercussions of demand misestimation under the 18th Electric Power Survey. Planned large-scale thermal capacity addition based on potentially ambitious demand growth estimates pushed the sector into a decade long downcycle between FY10-21, and excess capacity led to a serious stressed asset situation.

However, we draw comfort from the following:

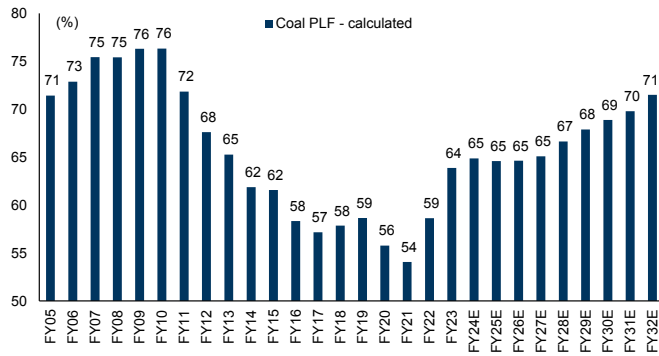
1. Demand estimation by government has been much more conservative since the 18th EPS miss. In fact, 19th EPS's FY17 peak demand estimates were in line, while FY22 estimates missed due to Covid impact.
2. Achievement of universal electrification under the SAUBHAGYA scheme and secular rise in appliance penetration (especially air conditioners) should drive a structural increase in peak power demand.
3. Lastly, emergence of 'new demand' from EV charging, datacenters, railway electrification, and universal tap water supply under the government's Jal se Jal program will provide new demand drivers.

Exhibit 62: 18th Electric Power Survey (EPS) overestimated peak demand growth, potentially influenced by the strong prevailing economic growth sentiment; however, 19th EPS forecasts much closer to actuals



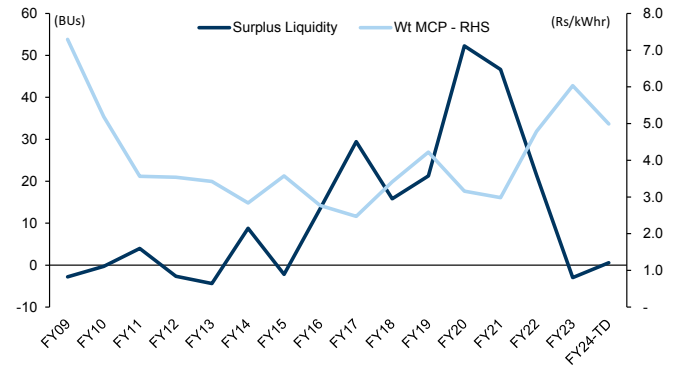
Source: CEA, Goldman Sachs Global Investment Research

Exhibit 63: Sharp decline in coal PLF indicative of oversupply condition during the previous decade but situation reversing FY22 onwards...



Source: CEA, Goldman Sachs Global Investment Research

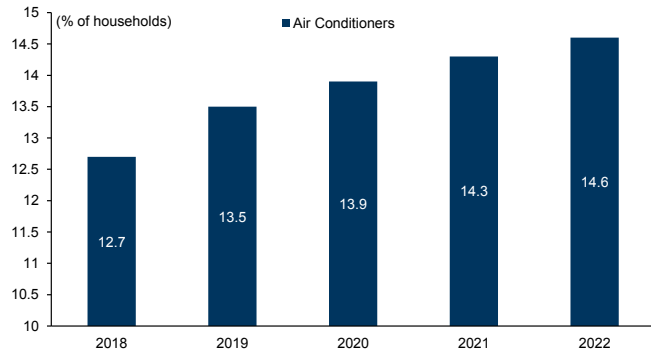
Exhibit 64: ...as highlighted by spot market liquidity and price movements



*BU - billion kWhr, MCP - Market Clearing Price

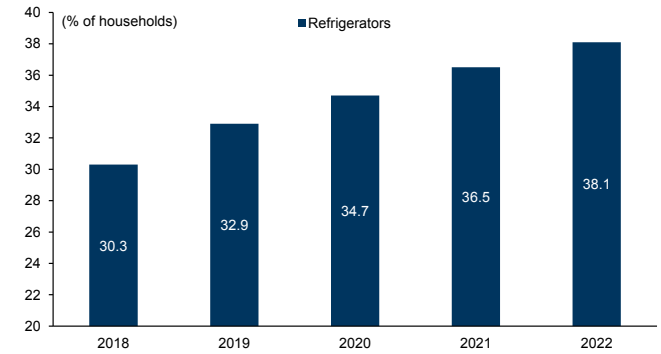
Source: IEX, Goldman Sachs Global Investment Research

Exhibit 65: Air-conditioner penetration rates



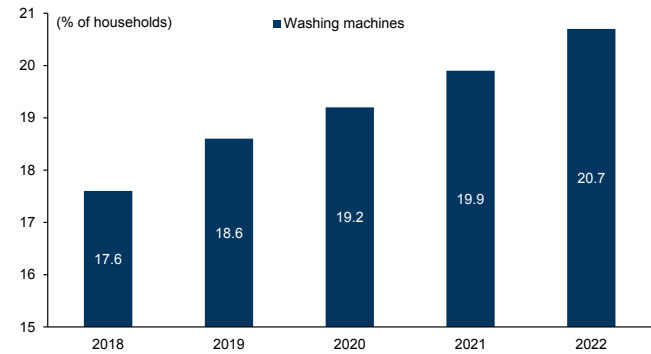
Source: Euromonitor, Goldman Sachs Global Investment Research

Exhibit 66: Refrigerator penetration rates



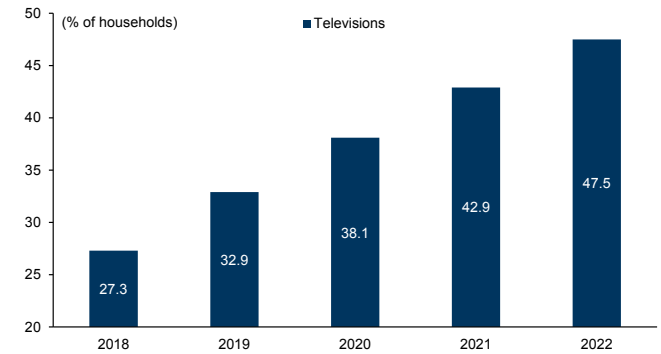
Source: Euromonitor, Goldman Sachs Global Investment Research

Exhibit 67: Washing machine penetration rates



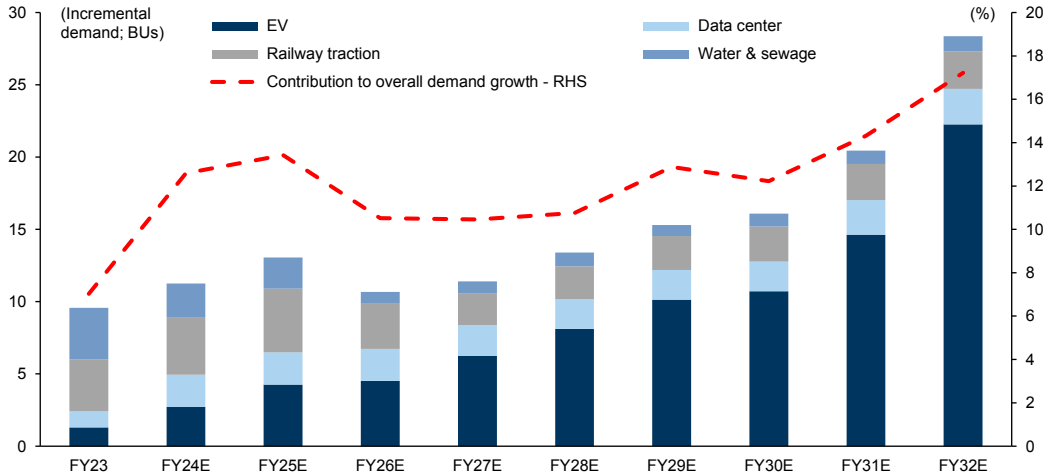
Source: Euromonitor, Goldman Sachs Global Investment Research

Exhibit 68: Television penetration rates



Source: Euromonitor, Goldman Sachs Global Investment Research

Exhibit 69: Rise in contribution from 'new demand' to aid overall electricity demand growth



Source: CEA, Goldman Sachs Global Investment Research

Disclosure Appendix

Reg AC

We, Apoorva Bahadur and Nikhil Bhandari, hereby certify that all of the views expressed in this report accurately reflect our personal views about the subject company or companies and its or their securities. We also certify that no part of our compensation was, is or will be, directly or indirectly, related to the specific recommendations or views expressed in this report.

Unless otherwise stated, the individuals listed on the cover page of this report are analysts in Goldman Sachs' Global Investment Research division.

GS Factor Profile

The Goldman Sachs Factor Profile provides investment context for a stock by comparing key attributes to the market (i.e. our coverage universe) and its sector peers. The four key attributes depicted are: Growth, Financial Returns, Multiple (e.g. valuation) and Integrated (a composite of Growth, Financial Returns and Multiple). Growth, Financial Returns and Multiple are calculated by using normalized ranks for specific metrics for each stock. The normalized ranks for the metrics are then averaged and converted into percentiles for the relevant attribute. The precise calculation of each metric may vary depending on the fiscal year, industry and region, but the standard approach is as follows:

Growth is based on a stock's forward-looking sales growth, EBITDA growth and EPS growth (for financial stocks, only EPS and sales growth), with a higher percentile indicating a higher growth company. **Financial Returns** is based on a stock's forward-looking ROE, ROCE and CROCI (for financial stocks, only ROE), with a higher percentile indicating a company with higher financial returns. **Multiple** is based on a stock's forward-looking P/E, P/B, price/dividend (P/D), EV/EBITDA, EV/FCF and EV/Debt Adjusted Cash Flow (DACF) (for financial stocks, only P/E, P/B and P/D), with a higher percentile indicating a stock trading at a higher multiple. The **Integrated** percentile is calculated as the average of the Growth percentile, Financial Returns percentile and (100% - Multiple percentile).

Financial Returns and Multiple use the Goldman Sachs analyst forecasts at the fiscal year-end at least three quarters in the future. Growth uses inputs for the fiscal year at least seven quarters in the future compared with the year at least three quarters in the future (on a per-share basis for all metrics).

For a more detailed description of how we calculate the GS Factor Profile, please contact your GS representative.

M&A Rank

Across our global coverage, we examine stocks using an M&A framework, considering both qualitative factors and quantitative factors (which may vary across sectors and regions) to incorporate the potential that certain companies could be acquired. We then assign a M&A rank as a means of scoring companies under our rated coverage from 1 to 3, with 1 representing high (30%-50%) probability of the company becoming an acquisition target, 2 representing medium (15%-30%) probability and 3 representing low (0%-15%) probability. For companies ranked 1 or 2, in line with our standard departmental guidelines we incorporate an M&A component into our target price. M&A rank of 3 is considered immaterial and therefore does not factor into our price target, and may or may not be discussed in research.

Quantum

Quantum is Goldman Sachs' proprietary database providing access to detailed financial statement histories, forecasts and ratios. It can be used for in-depth analysis of a single company, or to make comparisons between companies in different sectors and markets.

Disclosures

The rating(s) for NTPC Ltd., SJVN Ltd. and Tata Power is/are relative to the other companies in its/their coverage universe: NTPC Ltd., SJVN Ltd., Tata Power

Company-specific regulatory disclosures

The following disclosures relate to relationships between The Goldman Sachs Group, Inc. (with its affiliates, "Goldman Sachs") and companies covered by Goldman Sachs Global Investment Research and referred to in this research.

Goldman Sachs has received compensation for investment banking services in the past 12 months: Tata Power (Rs221.50)

Goldman Sachs expects to receive or intends to seek compensation for investment banking services in the next 3 months: NTPC Ltd. (Rs187.20) and Tata Power (Rs221.50)

Goldman Sachs had an investment banking services client relationship during the past 12 months with: NTPC Ltd. (Rs187.20) and Tata Power (Rs221.50)

There are no company-specific disclosures for: SJVN Ltd. (Rs45.80)

Distribution of ratings/investment banking relationships

Goldman Sachs Investment Research global Equity coverage universe

	Rating Distribution			Investment Banking Relationships		
	Buy	Hold	Sell	Buy	Hold	Sell
Global	48%	36%	16%	63%	56%	47%

As of July 1, 2023, Goldman Sachs Global Investment Research had investment ratings on 3,008 equity securities. Goldman Sachs assigns stocks as Buys and Sells on various regional Investment Lists; stocks not so assigned are deemed Neutral. Such assignments equate to Buy, Hold and Sell for the purposes of the above disclosure required by the FINRA Rules. See 'Ratings, Coverage universe and related definitions' below. The Investment Banking Relationships chart reflects the percentage of subject companies within each rating category for whom Goldman Sachs has provided investment banking services within the previous twelve months.

Regulatory disclosures

Disclosures required by United States laws and regulations

See company-specific regulatory disclosures above for any of the following disclosures required as to companies referred to in this report: manager or co-manager in a pending transaction; 1% or other ownership; compensation for certain services; types of client relationships; managed/co-managed public offerings in prior periods; directorships; for equity securities, market making and/or specialist role. Goldman Sachs trades or may trade as a principal in debt securities (or in related derivatives) of issuers discussed in this report.

The following are additional required disclosures: **Ownership and material conflicts of interest:** Goldman Sachs policy prohibits its analysts, professionals reporting to analysts and members of their households from owning securities of any company in the analyst's area of coverage. **Analyst compensation:** Analysts are paid in part based on the profitability of Goldman Sachs, which includes investment banking revenues. **Analyst as officer or director:** Goldman Sachs policy generally prohibits its analysts, persons reporting to analysts or members of their households from serving as an officer, director or advisor of any company in the analyst's area of coverage. **Non-U.S. Analysts:** Non-U.S. analysts may not be associated persons of Goldman Sachs & Co. LLC and therefore may not be subject to FINRA Rule 2241 or FINRA Rule 2242 restrictions on communications with subject company, public appearances and trading securities held by the analysts.

Distribution of ratings: See the distribution of ratings disclosure above. **Price chart:** See the price chart, with changes of ratings and price targets in prior periods, above, or, if electronic format or if with respect to multiple companies which are the subject of this report, on the Goldman Sachs website at <https://www.gs.com/research/hedge.html>.

Additional disclosures required under the laws and regulations of jurisdictions other than the United States

The following disclosures are those required by the jurisdiction indicated, except to the extent already made above pursuant to United States laws and regulations. **Australia:** Goldman Sachs Australia Pty Ltd and its affiliates are not authorised deposit-taking institutions (as that term is defined in the Banking Act 1959 (Cth)) in Australia and do not provide banking services, nor carry on a banking business, in Australia. This research, and any access to it, is intended only for "wholesale clients" within the meaning of the Australian Corporations Act, unless otherwise agreed by Goldman Sachs. In producing research reports, members of Global Investment Research of Goldman Sachs Australia may attend site visits and other meetings hosted by the companies and other entities which are the subject of its research reports. In some instances the costs of such site visits or meetings may be met in part or in whole by the issuers concerned if Goldman Sachs Australia considers it is appropriate and reasonable in the specific circumstances relating to the site visit or meeting. To the extent that the contents of this document contains any financial product advice, it is general advice only and has been prepared by Goldman Sachs without taking into account a client's objectives, financial situation or needs. A client should, before acting on any such advice, consider the appropriateness of the advice having regard to the client's own objectives, financial situation and needs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests and a copy of Goldman Sachs' Australian Sell-Side Research Independence Policy Statement are available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Brazil:** Disclosure information in relation to CVM Resolution n. 20 is available at <https://www.gs.com/worldwide/brazil/area/gir/index.html>. Where applicable, the Brazil-registered analyst primarily responsible for the content of this research report, as defined in Article 20 of CVM Resolution n. 20, is the first author named at the beginning of this report, unless indicated otherwise at the end of the text. **Canada:** This information is being provided to you for information purposes only and is not, and under no circumstances should be construed as, an advertisement, offering or solicitation by Goldman Sachs & Co. LLC for purchasers of securities in Canada to trade in any Canadian security. Goldman Sachs & Co. LLC is not registered as a dealer in any jurisdiction in Canada under applicable Canadian securities laws and generally is not permitted to trade in Canadian securities and may be prohibited from selling certain securities and products in certain jurisdictions in Canada. If you wish to trade in any Canadian securities or other products in Canada please contact Goldman Sachs Canada Inc., an affiliate of The Goldman Sachs Group Inc., or another registered Canadian dealer. **Hong Kong:** Further information on the securities of covered companies referred to in this research may be obtained on request from Goldman Sachs (Asia) L.L.C. **India:** Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (India) Securities Private Limited, Research Analyst - SEBI Registration Number INH000001493, 951-A, Rational House, Appasaheb Marathe Marg, Prabhadevi, Mumbai 400 025, India, Corporate Identity Number U74140MH2006FTC160634, Phone +91 22 6616 9000, Fax +91 22 6616 9001. Goldman Sachs may beneficially own 1% or more of the securities (as such term is defined in clause 2 (h) the Indian Securities Contracts (Regulation) Act, 1956) of the subject company or companies referred to in this research report. **Japan:** See below. **Korea:** This research, and any access to it, is intended only for "professional investors" within the meaning of the Financial Services and Capital Markets Act, unless otherwise agreed by Goldman Sachs. Further information on the subject company or companies referred to in this research may be obtained from Goldman Sachs (Asia) L.L.C., Seoul Branch. **New Zealand:** Goldman Sachs New Zealand Limited and its affiliates are neither "registered banks" nor "deposit takers" (as defined in the Reserve Bank of New Zealand Act 1989) in New Zealand. This research, and any access to it, is intended for "wholesale clients" (as defined in the Financial Advisers Act 2008) unless otherwise agreed by Goldman Sachs. A copy of certain Goldman Sachs Australia and New Zealand disclosure of interests is available at: <https://www.goldmansachs.com/disclosures/australia-new-zealand/index.html>. **Russia:** Research reports distributed in the Russian Federation are not advertising as defined in the Russian legislation, but are information and analysis not having product promotion as their main purpose and do not provide appraisal within the meaning of the Russian legislation on appraisal activity. Research reports do not constitute a personalized investment recommendation as defined in Russian laws and regulations, are not addressed to a specific client, and are prepared without analyzing the financial

circumstances, investment profiles or risk profiles of clients. Goldman Sachs assumes no responsibility for any investment decisions that may be taken by a client or any other person based on this research report. **Singapore:** Goldman Sachs (Singapore) Pte. (Company Number: 198602165W), which is regulated by the Monetary Authority of Singapore, accepts legal responsibility for this research, and should be contacted with respect to any matters arising from, or in connection with, this research. **Taiwan:** This material is for reference only and must not be reprinted without permission. Investors should carefully consider their own investment risk. Investment results are the responsibility of the individual investor. **United Kingdom:** Persons who would be categorized as retail clients in the United Kingdom, as such term is defined in the rules of the Financial Conduct Authority, should read this research in conjunction with prior Goldman Sachs research on the covered companies referred to herein and should refer to the risk warnings that have been sent to them by Goldman Sachs International. A copy of these risks warnings, and a glossary of certain financial terms used in this report, are available from Goldman Sachs International on request.

European Union and United Kingdom: Disclosure information in relation to Article 6 (2) of the European Commission Delegated Regulation (EU) (2016/958) supplementing Regulation (EU) No 596/2014 of the European Parliament and of the Council (including as that Delegated Regulation is implemented into United Kingdom domestic law and regulation following the United Kingdom's departure from the European Union and the European Economic Area) with regard to regulatory technical standards for the technical arrangements for objective presentation of investment recommendations or other information recommending or suggesting an investment strategy and for disclosure of particular interests or indications of conflicts of interest is available at <https://www.gs.com/disclosures/europeanpolicy.html> which states the European Policy for Managing Conflicts of Interest in Connection with Investment Research.

Japan: Goldman Sachs Japan Co., Ltd. is a Financial Instrument Dealer registered with the Kanto Financial Bureau under registration number Kinsho 69, and a member of Japan Securities Dealers Association, Financial Futures Association of Japan Type II Financial Instruments Firms Association, The Investment Trusts Association, Japan, and Japan Investment Advisers Association. Sales and purchase of equities are subject to commission pre-determined with clients plus consumption tax. See company-specific disclosures as to any applicable disclosures required by Japanese stock exchanges, the Japanese Securities Dealers Association or the Japanese Securities Finance Company.

Ratings, coverage universe and related definitions

Buy (B), Neutral (N), Sell (S) Analysts recommend stocks as Buys or Sells for inclusion on various regional Investment Lists. Being assigned a Buy or Sell on an Investment List is determined by a stock's total return potential relative to its coverage universe. Any stock not assigned as a Buy or a Sell on an Investment List with an active rating (i.e., a stock that is not Rating Suspended, Not Rated, Coverage Suspended or Not Covered), is deemed Neutral. Each region manages Regional Conviction lists, which are selected from Buy rated stocks on the respective region's Investment lists and represent investment recommendations focused on the size of the total return potential and/or the likelihood of the realization of the return across their respective areas of coverage. The addition or removal of stocks from such Conviction lists are managed by the Investment Review Committee or other designated committee in each respective region and do not represent a change in the analysts' investment rating for such stocks.

Total return potential represents the upside or downside differential between the current share price and the price target, including all paid or anticipated dividends, expected during the time horizon associated with the price target. Price targets are required for all covered stocks. The total return potential, price target and associated time horizon are stated in each report adding or reiterating an Investment List membership.

Coverage Universe: A list of all stocks in each coverage universe is available by primary analyst, stock and coverage universe at <https://www.gs.com/research/hedge.html>.

Not Rated (NR). The investment rating, target price and earnings estimates (where relevant) have been suspended pursuant to Goldman Sachs policy when Goldman Sachs is acting in an advisory capacity in a merger or in a strategic transaction involving this company, when there are legal, regulatory or policy constraints due to Goldman Sachs' involvement in a transaction, and in certain other circumstances. **Rating Suspended (RS).** Goldman Sachs Research has suspended the investment rating and price target for this stock, because there is not a sufficient fundamental basis for determining an investment rating or target price. The previous investment rating and target price, if any, are no longer in effect for this stock and should not be relied upon. **Coverage Suspended (CS).** Goldman Sachs has suspended coverage of this company. **Not Covered (NC).** Goldman Sachs does not cover this company. **Not Available or Not Applicable (NA).** The information is not available for display or is not applicable. **Not Meaningful (NM).** The information is not meaningful and is therefore excluded.

Global product; distributing entities

Goldman Sachs Global Investment Research produces and distributes research products for clients of Goldman Sachs on a global basis. Analysts based in Goldman Sachs offices around the world produce research on industries and companies, and research on macroeconomics, currencies, commodities and portfolio strategy. This research is disseminated in Australia by Goldman Sachs Australia Pty Ltd (ABN 21 006 797 897); in Brazil by Goldman Sachs do Brasil Corretora de Títulos e Valores Mobiliários S.A.; Public Communication Channel Goldman Sachs Brazil: 0800 727 5764 and / or contatogoldmanbrasil@gs.com. Available Weekdays (except holidays), from 9am to 6pm. Canal de Comunicação com o Público Goldman Sachs Brasil: 0800 727 5764 e/ou contatogoldmanbrasil@gs.com. Horário de funcionamento: segunda-feira à sexta-feira (exceto feriados), das 9h às 18h; in Canada by Goldman Sachs & Co. LLC; in Hong Kong by Goldman Sachs (Asia) L.L.C.; in India by Goldman Sachs (India) Securities Private Ltd.; in Japan by Goldman Sachs Japan Co., Ltd.; in the Republic of Korea by Goldman Sachs (Asia) L.L.C.; Seoul Branch; in New Zealand by Goldman Sachs New Zealand Limited; in Russia by OOO Goldman Sachs; in Singapore by Goldman Sachs (Singapore) Pte. (Company Number: 198602165W); and in the United States of America by Goldman Sachs & Co. LLC. Goldman Sachs International has approved this research in connection with its distribution in the United Kingdom.

Goldman Sachs International ("GSI"), authorised by the Prudential Regulation Authority ("PRA") and regulated by the Financial Conduct Authority ("FCA") and the PRA, has approved this research in connection with its distribution in the United Kingdom.

European Economic Area: GSI, authorised by the PRA and regulated by the FCA and the PRA, disseminates research in the following jurisdictions within the European Economic Area: the Grand Duchy of Luxembourg, Italy, the Kingdom of Belgium, the Kingdom of Denmark, the Kingdom of Norway, the Republic of Finland and the Republic of Ireland; GSI - Succursale de Paris (Paris branch) which is authorised by the French Autorité de contrôle prudentiel et de résolution ("ACPR") and regulated by the Autorité de contrôle prudentiel et de résolution and the Autorité des marchés financiers ("AMF") disseminates research in France; GSI - Succursale en España (Madrid branch) authorized in Spain by the Comisión Nacional del Mercado de Valores disseminates research in the Kingdom of Spain; GSI - Sweden Bankfilial (Stockholm branch) is authorized by the SFSF as a "third country branch" in accordance with Chapter 4, Section 4 of the Swedish Securities and Market Act (Sv. lag (2007:528) om värdepappersmarknaden) disseminates research in the Kingdom of Sweden; Goldman Sachs Bank Europe SE ("GSBE") is a credit institution incorporated in Germany and, within the Single Supervisory Mechanism, subject to direct prudential supervision by the European Central Bank and in other respects supervised by German Federal Financial Supervisory Authority (Bundesanstalt für Finanzdienstleistungsaufsicht, BaFin) and Deutsche Bundesbank and disseminates research in the Federal Republic of Germany and those jurisdictions within the European Economic Area where GSI is not authorised to disseminate research and additionally, GSBE, Copenhagen Branch filial af GSBE, Tyskland, supervised by the Danish Financial Authority disseminates research in the Kingdom of Denmark; GSBE - Succursale en España (Madrid branch) subject (to a limited extent) to local supervision by the Bank of Spain disseminates research in the Kingdom of Spain; GSBE - Succursale Italia (Milan branch) to the relevant applicable extent, subject to local supervision by the Bank of Italy (Banca d'Italia) and the Italian Companies and Exchange Commission (Commissione Nazionale per le Società e la Borsa "Consob") disseminates research in Italy; GSBE - Succursale de Paris (Paris branch), supervised by the AMF and by the ACPR disseminates research in France; and GSBE - Sweden

Bankfilial (Stockholm branch), to a limited extent, subject to local supervision by the Swedish Financial Supervisory Authority (Finansinspektionen) disseminates research in the Kingdom of Sweden.

General disclosures

This research is for our clients only. Other than disclosures relating to Goldman Sachs, this research is based on current public information that we consider reliable, but we do not represent it is accurate or complete, and it should not be relied on as such. The information, opinions, estimates and forecasts contained herein are as of the date hereof and are subject to change without prior notification. We seek to update our research as appropriate, but various regulations may prevent us from doing so. Other than certain industry reports published on a periodic basis, the large majority of reports are published at irregular intervals as appropriate in the analyst's judgment.

Goldman Sachs conducts a global full-service, integrated investment banking, investment management, and brokerage business. We have investment banking and other business relationships with a substantial percentage of the companies covered by Global Investment Research. Goldman Sachs & Co. LLC, the United States broker dealer, is a member of SIPC (<https://www.sipc.org>).

Our salespeople, traders, and other professionals may provide oral or written market commentary or trading strategies to our clients and principal trading desks that reflect opinions that are contrary to the opinions expressed in this research. Our asset management area, principal trading desks and investing businesses may make investment decisions that are inconsistent with the recommendations or views expressed in this research.

The analysts named in this report may have from time to time discussed with our clients, including Goldman Sachs salespersons and traders, or may discuss in this report, trading strategies that reference catalysts or events that may have a near-term impact on the market price of the equity securities discussed in this report, which impact may be directionally counter to the analyst's published price target expectations for such stocks. Any such trading strategies are distinct from and do not affect the analyst's fundamental equity rating for such stocks, which rating reflects a stock's return potential relative to its coverage universe as described herein.

We and our affiliates, officers, directors, and employees will from time to time have long or short positions in, act as principal in, and buy or sell, the securities or derivatives, if any, referred to in this research, unless otherwise prohibited by regulation or Goldman Sachs policy.

The views attributed to third party presenters at Goldman Sachs arranged conferences, including individuals from other parts of Goldman Sachs, do not necessarily reflect those of Global Investment Research and are not an official view of Goldman Sachs.

Any third party referenced herein, including any salespeople, traders and other professionals or members of their household, may have positions in the products mentioned that are inconsistent with the views expressed by analysts named in this report.

This research is not an offer to sell or the solicitation of an offer to buy any security in any jurisdiction where such an offer or solicitation would be illegal. It does not constitute a personal recommendation or take into account the particular investment objectives, financial situations, or needs of individual clients. Clients should consider whether any advice or recommendation in this research is suitable for their particular circumstances and, if appropriate, seek professional advice, including tax advice. The price and value of investments referred to in this research and the income from them may fluctuate. Past performance is not a guide to future performance, future returns are not guaranteed, and a loss of original capital may occur. Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

Certain transactions, including those involving futures, options, and other derivatives, give rise to substantial risk and are not suitable for all investors. Investors should review current options and futures disclosure documents which are available from Goldman Sachs sales representatives or at <https://www.theocc.com/about/publications/character-risks.jsp> and https://www.fiadocumentation.org/fia/regulatory-disclosures_1/fia-uniform-futures-and-options-on-futures-risk-disclosures-booklet-version-2018. Transaction costs may be significant in option strategies calling for multiple purchase and sales of options such as spreads. Supporting documentation will be supplied upon request.

Differing Levels of Service provided by Global Investment Research: The level and types of services provided to you by Goldman Sachs Global Investment Research may vary as compared to that provided to internal and other external clients of GS, depending on various factors including your individual preferences as to the frequency and manner of receiving communication, your risk profile and investment focus and perspective (e.g., marketwide, sector specific, long term, short term), the size and scope of your overall client relationship with GS, and legal and regulatory constraints. As an example, certain clients may request to receive notifications when research on specific securities is published, and certain clients may request that specific data underlying analysts' fundamental analysis available on our internal client websites be delivered to them electronically through data feeds or otherwise. No change to an analyst's fundamental research views (e.g., ratings, price targets, or material changes to earnings estimates for equity securities), will be communicated to any client prior to inclusion of such information in a research report broadly disseminated through electronic publication to our internal client websites or through other means, as necessary, to all clients who are entitled to receive such reports.

All research reports are disseminated and available to all clients simultaneously through electronic publication to our internal client websites. Not all research content is redistributed to our clients or available to third-party aggregators, nor is Goldman Sachs responsible for the redistribution of our research by third party aggregators. For research, models or other data related to one or more securities, markets or asset classes (including related services) that may be available to you, please contact your GS representative or go to <https://research.gs.com>.

Disclosure information is also available at <https://www.gs.com/research/hedge.html> or from Research Compliance, 200 West Street, New York, NY 10282.

© 2023 Goldman Sachs.

No part of this material may be (i) copied, photocopied or duplicated in any form by any means or (ii) redistributed without the prior written consent of The Goldman Sachs Group, Inc.