Preparing for the energy transition

Alexander Hogeveen Rutter

Lots to be proud of in the journey so far

- ~100% village electrification
- Robust Financial system for RE financing-DFIs no longer needed, at least for large-scale solar/wind
- World-leading framework for Open Access PPAs
- Reliability comparable to US/Canada, at least in major metros
- Improved Frequency/voltage performance
- Certain states (eg. Karnataka with 15 GW) already have RE at a significant levels, resulting in no energy deficit even during the current energy crisis. With a population comparable to UK, Karnataka also has comparable RE%-can learn from within!
- Time to chart India's journey forward, based on what is best for Indian consumers, but also a tremendous opportunity to be a leader for the rest of the developing world

India should chart a path based on what is best for India, and not feel obliged to follow the same mistakes as the West. There is a huge opportunity for a technological leapfrog

Current Scenario to 2030

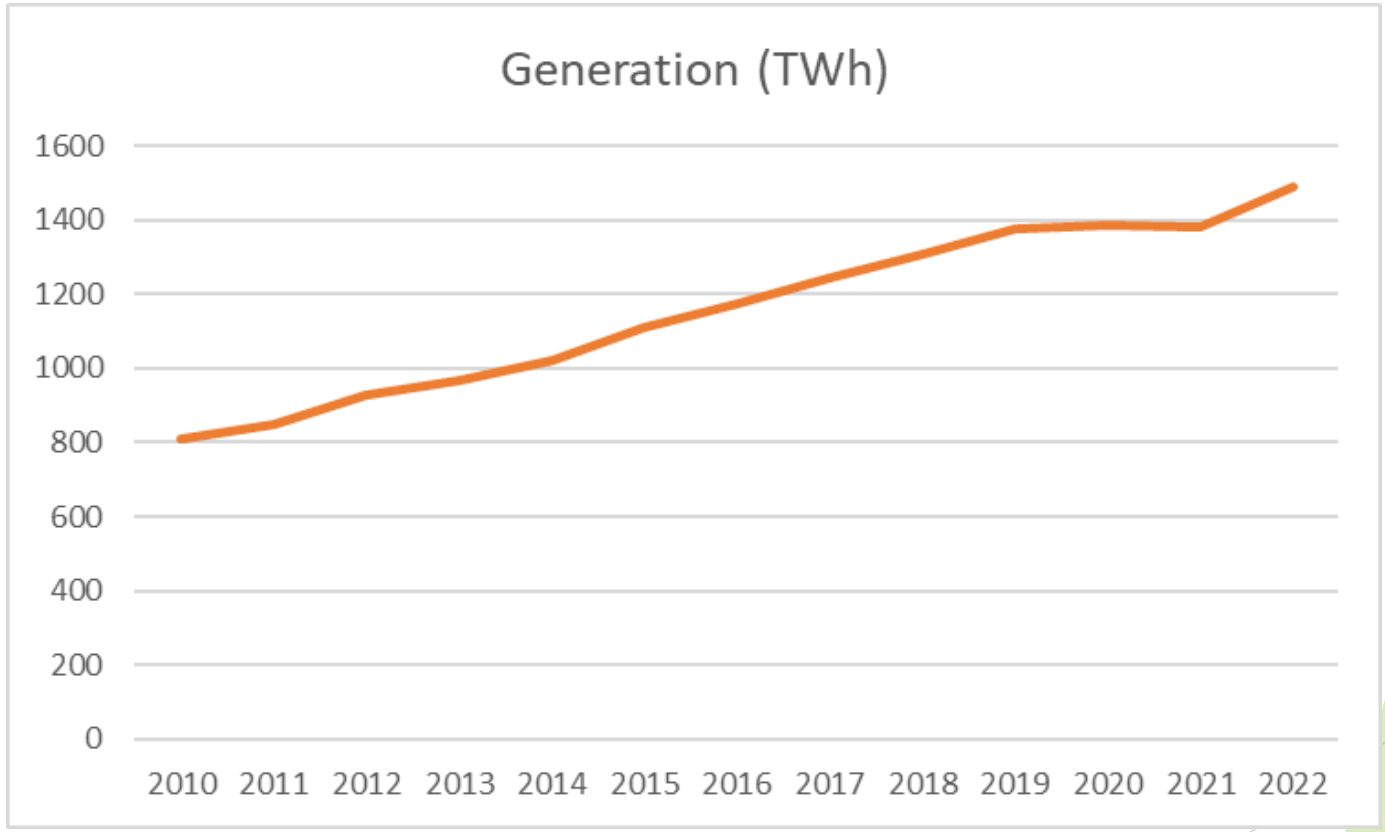
"Energy access should not be the privilege of the rich" – PM Modi

How do we provide lowest cost power to the average Indian consumer?

What is the cheapest way to ensure that power is reliable?

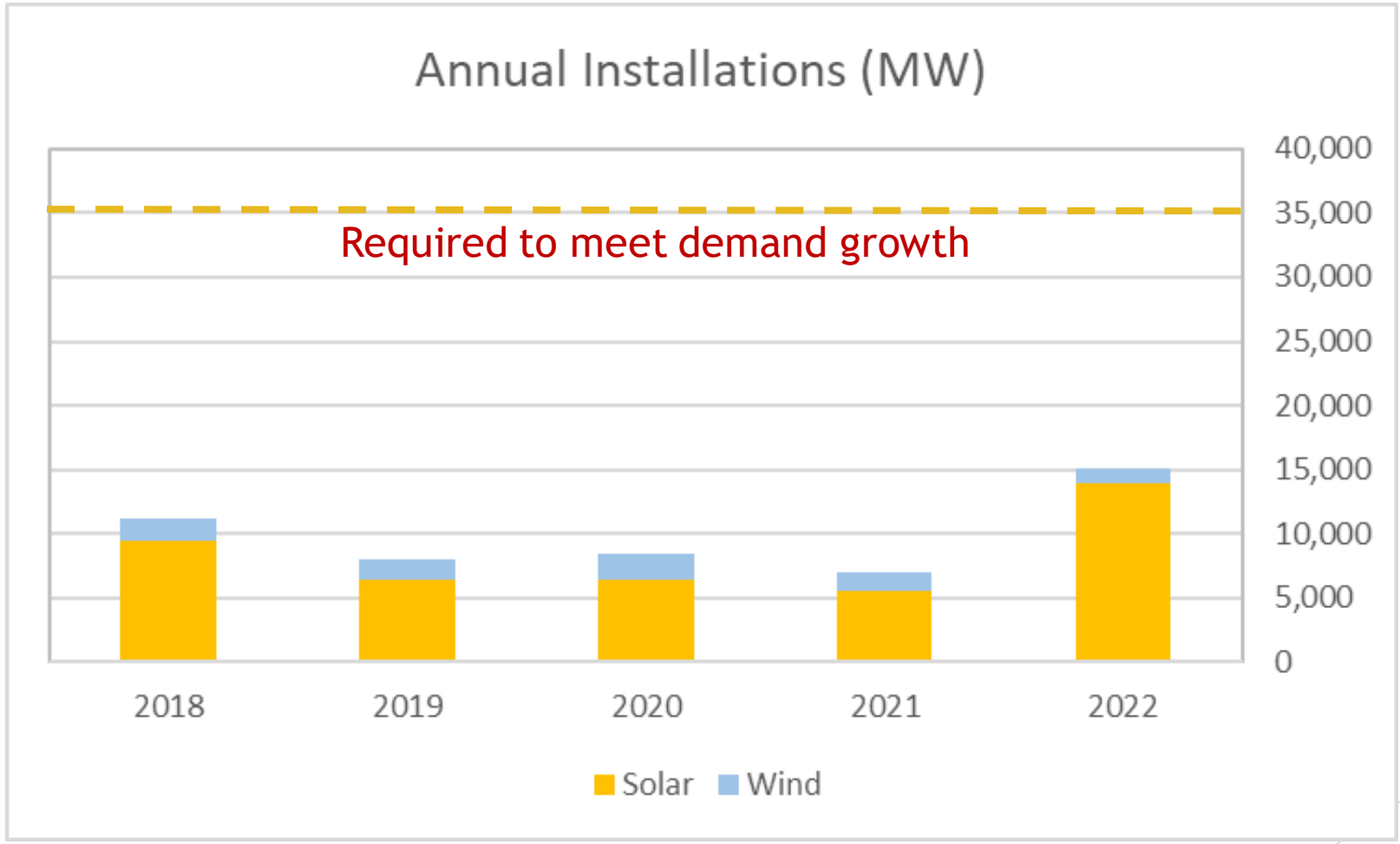
New solar and wind are cheaper than new coal

But Demand is growing faster than RE is being deployed



Despite covid, there has been an average 5.2%/year rise in consumption, ~80 TWh/year

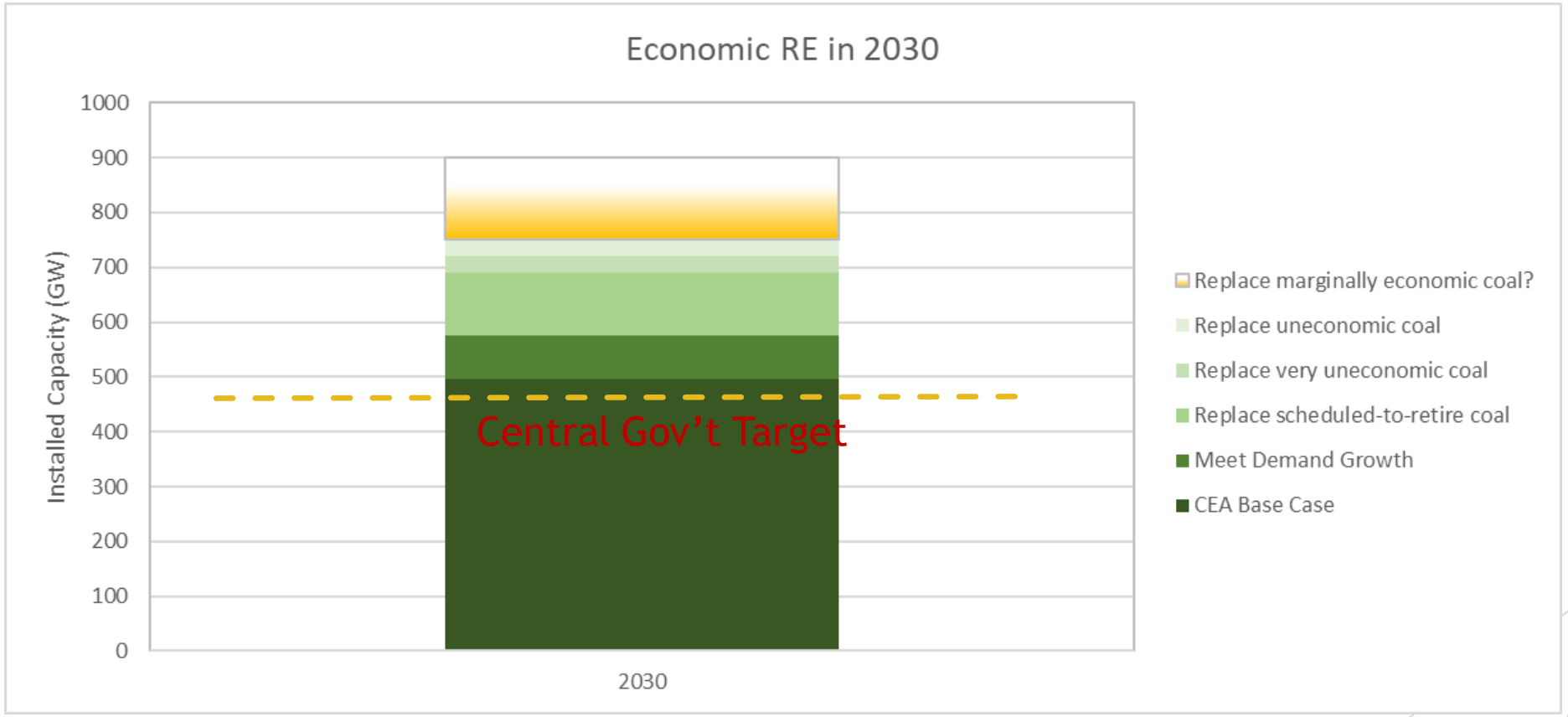
Actual installations have lagged far behind demand growth



80 TWh at ~25% CUF corresponds to 35 GW of RE/year. Just for demand growth alone!

Does not include electrifying industrial processes, retiring expensive coal, etc.

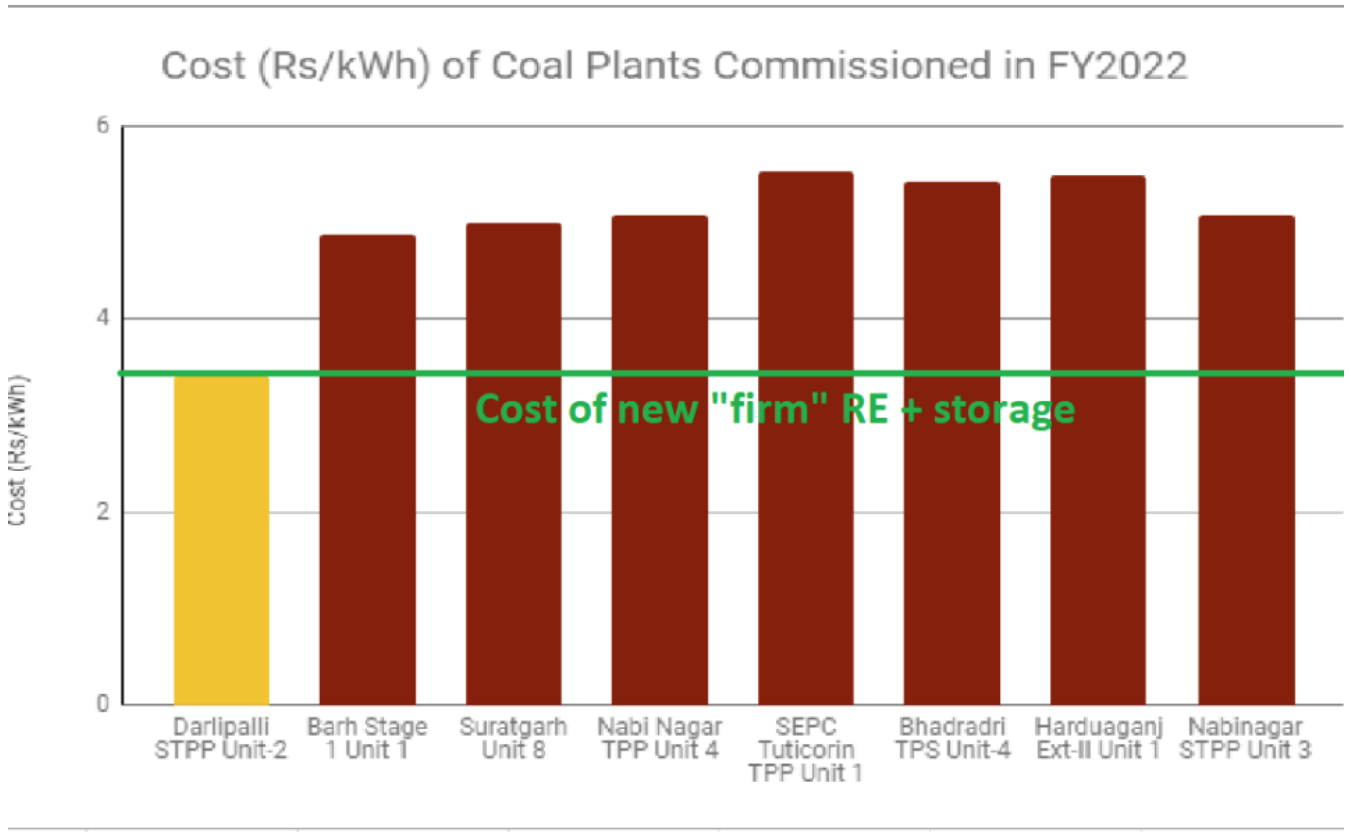
India needs to significantly ramp up RE Deployment, for economic reasons alone



Does not include:

- Green Hydrogen
- Captive Generation
- EV ramp up
- Price declines in RE + storage making more coal uneconomic

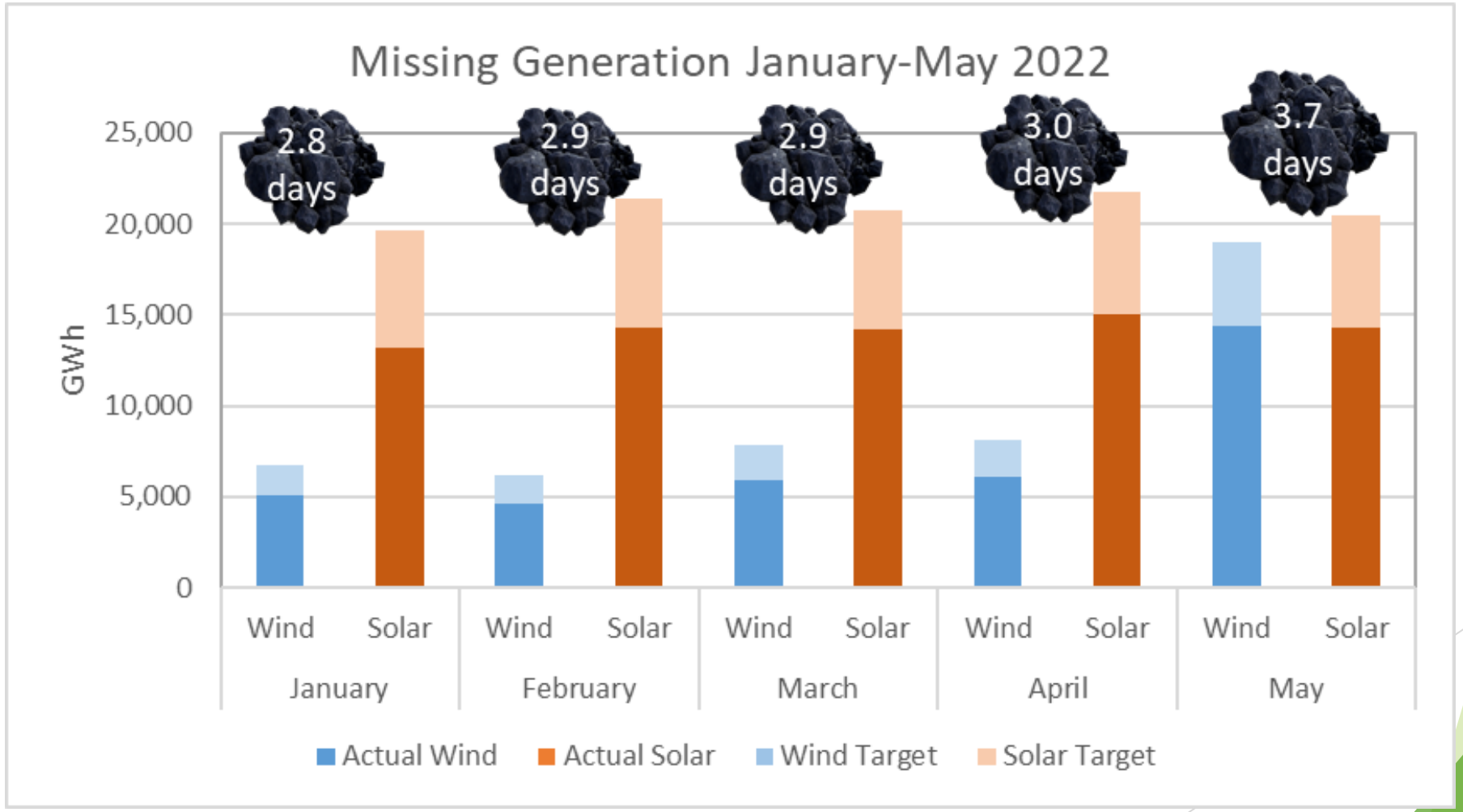
Instead, Indians continue to be burdened with new coal projects-for the next 25+ Years



Building these coal plants instead of RE + storage will cost Indian consumers at least* Rs. 3300 Cr per year for the next 25 years

- Many recently built plants (Wanakbori, Solapur, Kudgi, Harduaganj, etc.) have variable costs that are above the cost of new RE + storage
- In some cases (eg. Tuticorin) there is 100% pass-through of imported fuel costs, so the current price is more like Rs. 11.5/unit
- Many people tend to compare legacy fully amortized coal vs. new RE + storage-this is not a valid comparison! (unless talking about premature shut-down)

The energy crisis this summer was primarily an energy shortage

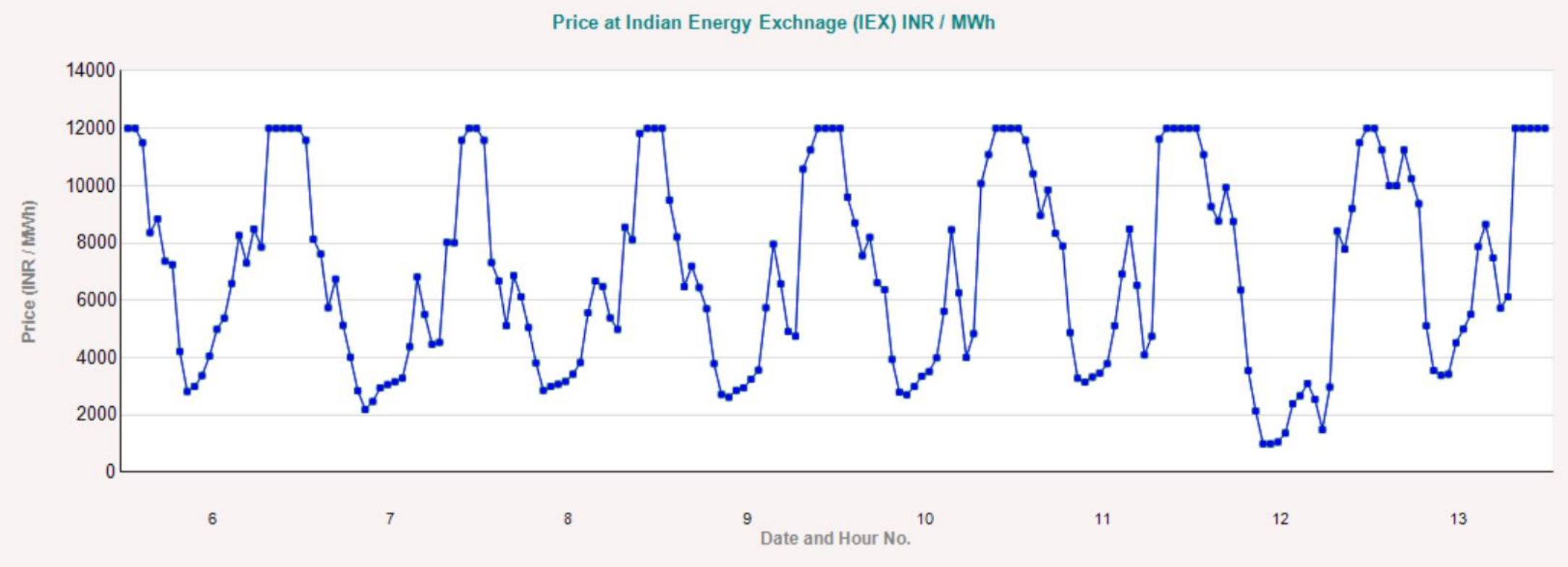


If the shortage is energy only, wind + solar alone would be sufficient.

In fact, in May the peak was during the day 27/31 days, so solar was meeting the peak

Need to rapidly build solar/wind to avoid similar shortage in 2023 or 2024 (and potentially storage for peaking)

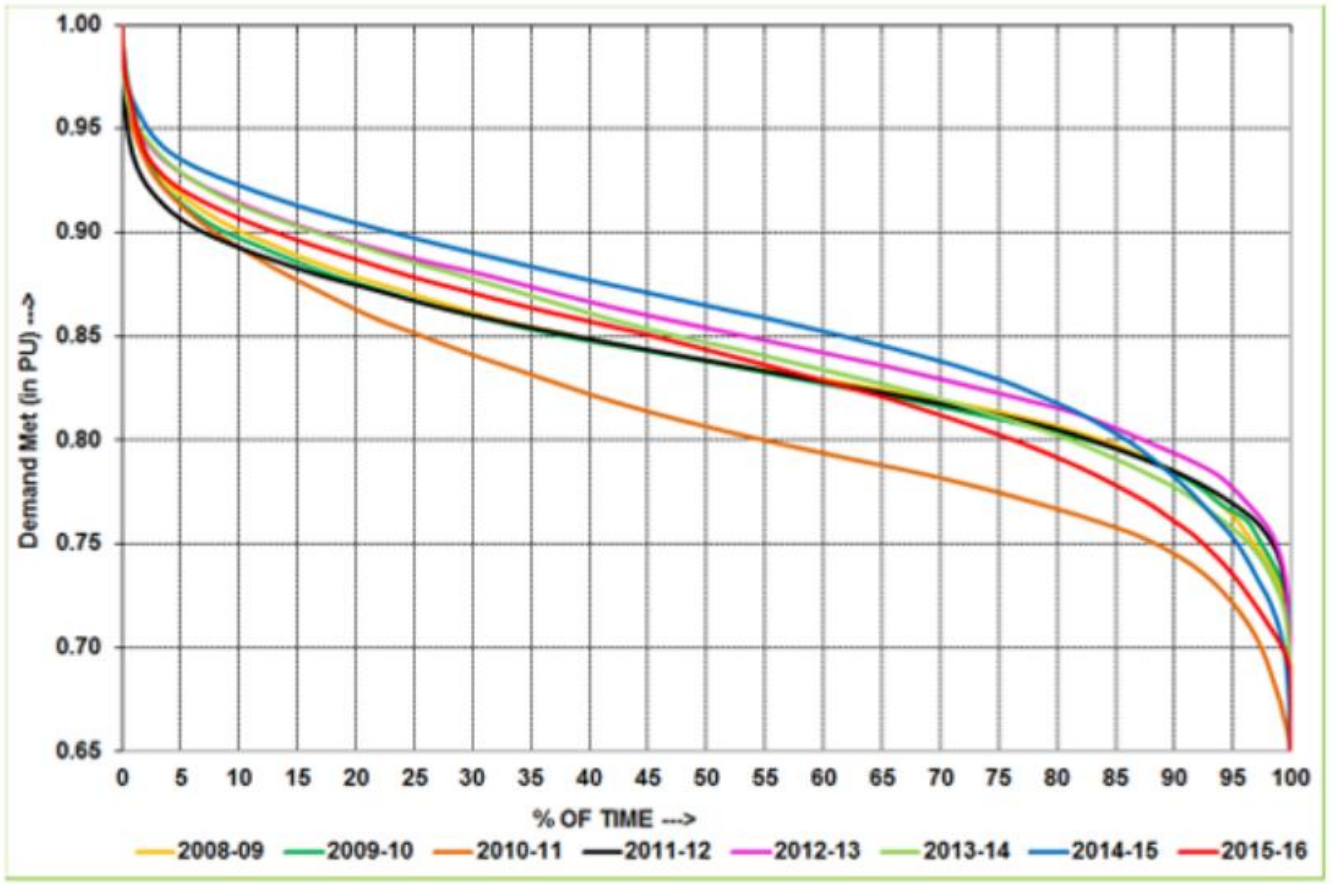
However in some weeks, peaks were an issue



Typical peak this June was 3-4 hours at night. Building more wind would help, but cannot guarantee power. Peaking resource is required!

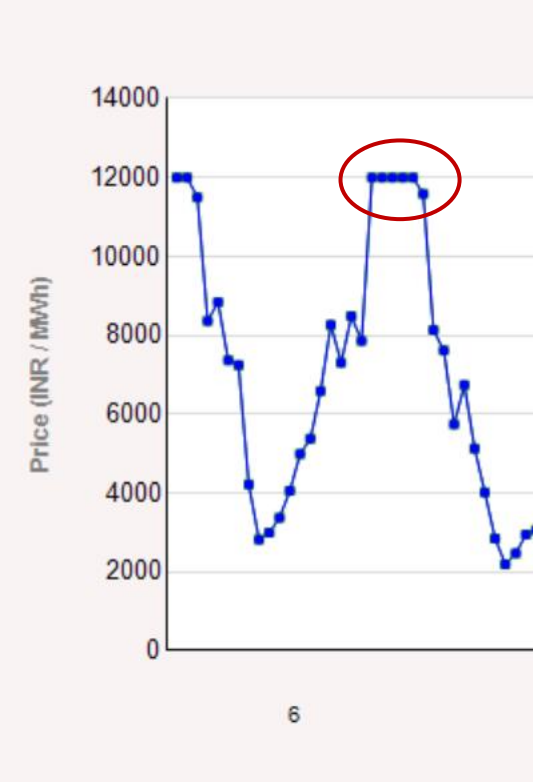
LOAD CURVE (even Pre-VRE) shows the fallacy of “RTC” power

3.2. Annual Demand Duration Curve: Normalised with respect to Maximum Demand met (occurred during the respective year)



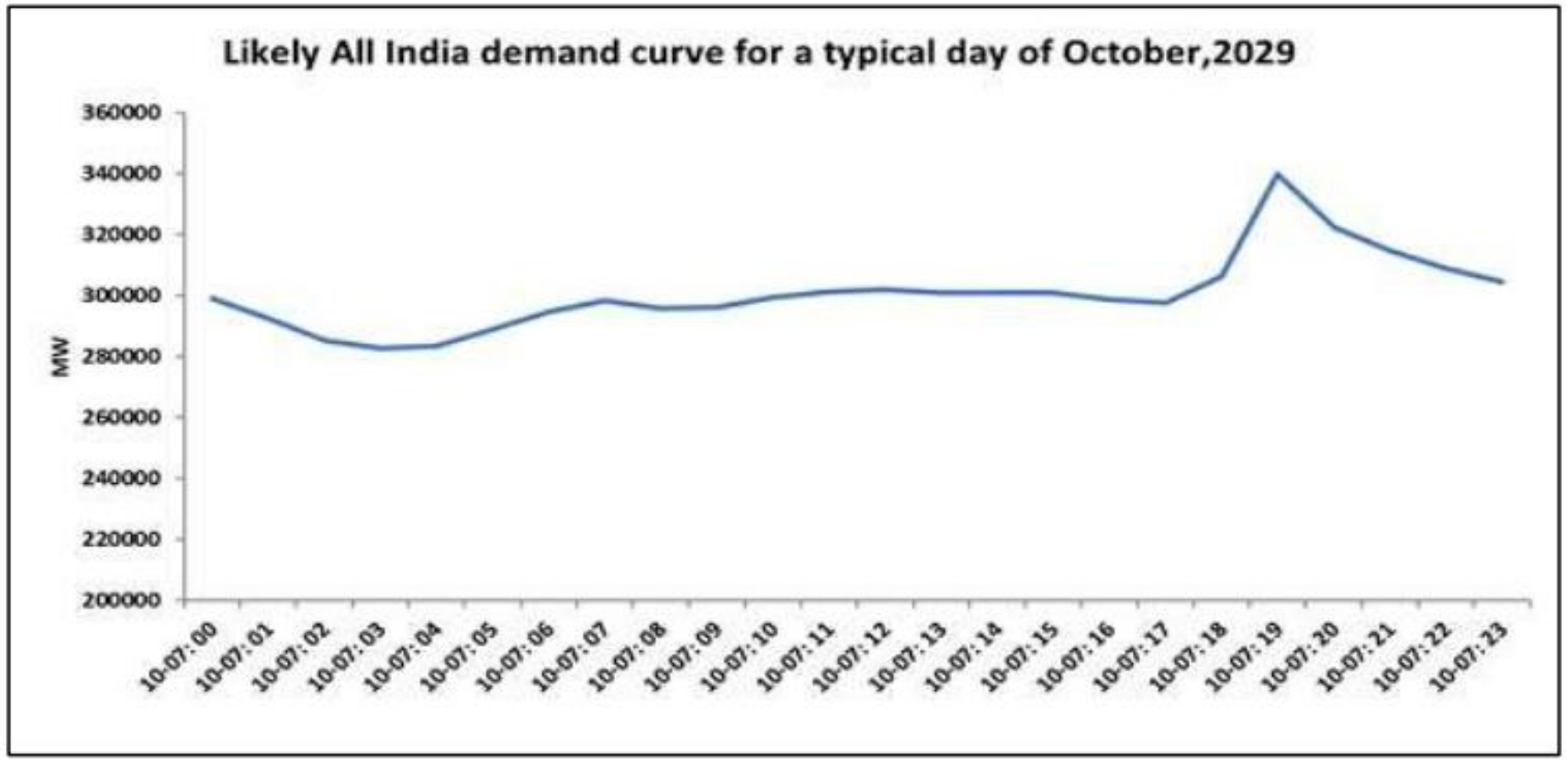
- 10% of Generation needed <15% of the time
- Load factor has actually been decreasing since 2016 (perhaps as unmet demand is now being met)
- In Ontario, 20% of the generation is used <10%. Will India evolve in this direction as more ACs are built?

Sometimes people get confused and compare coal “baseload” price vs. RE “Peaking” Price

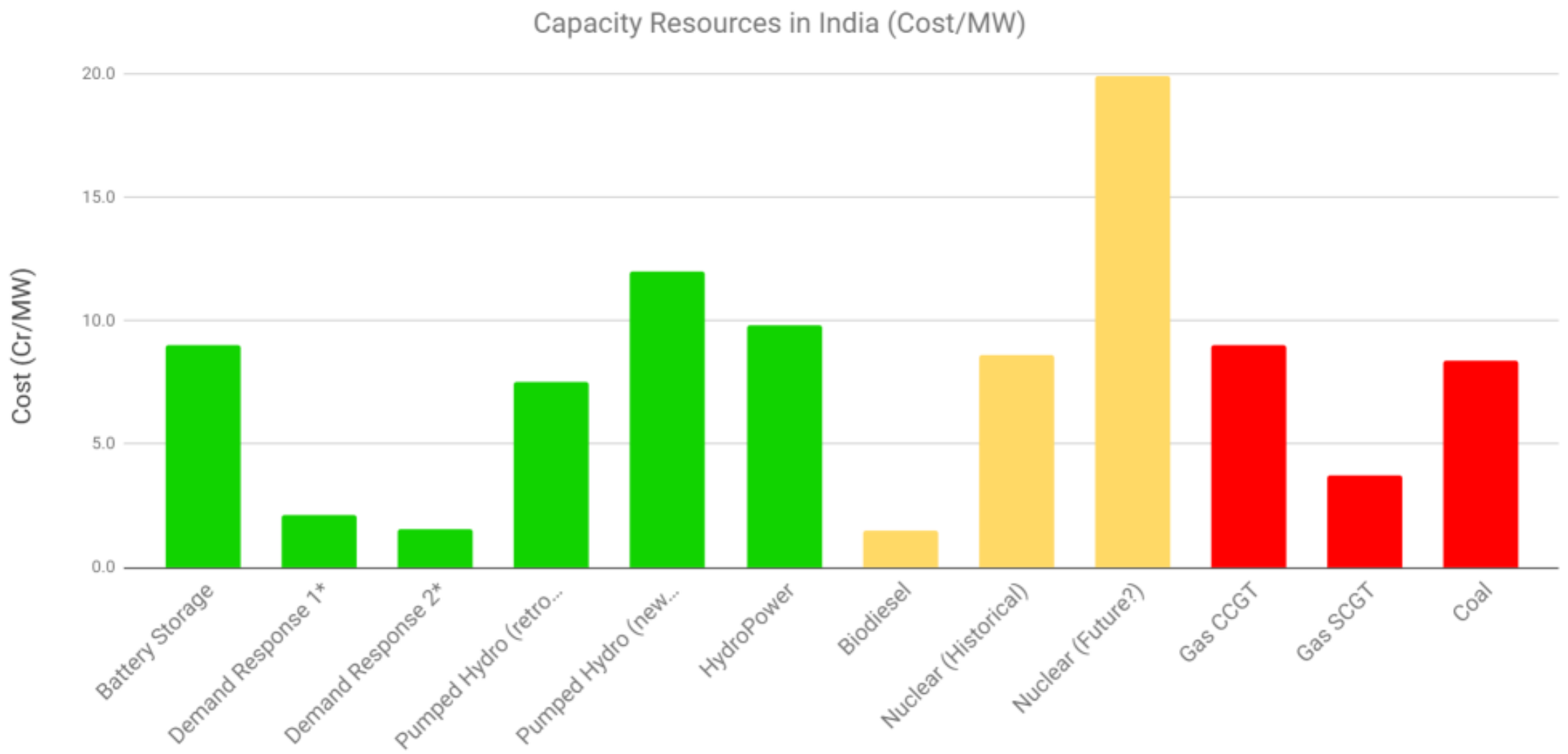


- No DISCOM anywhere in the world has a flat load curve
- Coal (especially supercritical/ultracritical) is not well-suited to meet capacity needs. Building a coal plant to meet 3 hour peaks effectively increase FC 6x, so say Rs 15/unit (on top of the variable cost)
- Building “Baseload” coal means either it is extremely expensive for peaking or there is not enough peaking capacity. While the rich can compensate with diesel gensets, the poor are left with lower reliability and everyone gets higher prices. Building peaking capacity is an equity/energy access issue

Remember, load is not flat!



Comparison of new capacity resource cost



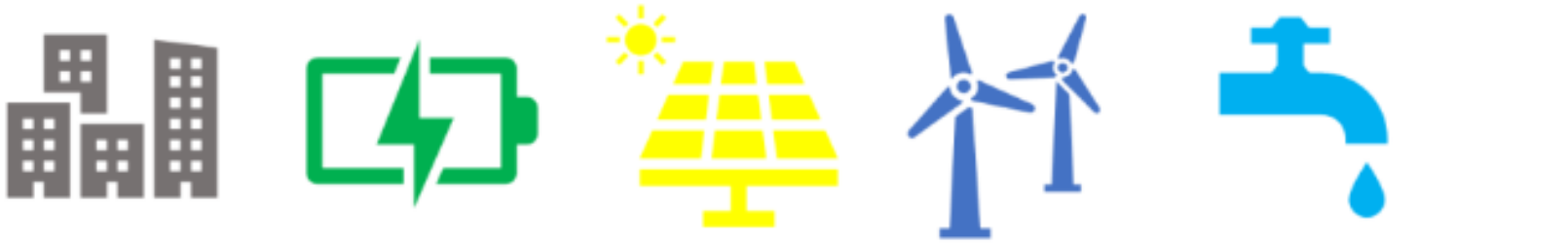
Only a handful of the coal plants built in the last 5 years have been economic for energy or capacity, and none for both.

The best time to start building RE instead of coal was 5 years ago!

Year	Name	Cost (Cr)	Capacity (MW)	Cost (Cr/MW)	VC (Rs/kWh)
2019	Chhabra 5 & 6	9750	1320	7.39	2.19
2017	Prayagrah	15537	1980	7.85	2.30
2021	Tanda TPS	12676	1320	9.60	2.61
2017	UNCHAHAR TP	3472	500	6.94	2.98
2021	Meja STPP	10821	1320	8.20	2.23
2018	Akaltara TPS	27080	1800	15.04	5.04
2019	Uchpinda TPP	12668	1440	8.80	5.35
2017	Nawapara TPP	5673	600	9.46	2.25
2018	Binjkote TPP	4892	600	8.15	4.24
2019	Wanakbori 8	4268	800	5.34	3.70
2017	Bhavnagar CFB	3615	500	7.23	3.14
2019	Shri Singhaji II	7738	1320	5.86	6.38
2018	Mahan TPP	9000	1200	7.50	1.72
2017	Nasik TPS	9302	1350	6.89	3.27
2020	Lara TPP	12000	1600	7.50	2.08
2019	Darlipali	13700	1600	8.56	1.34
2020	Khargone STPP	11149	1320	8.45	4.63
2021	Gadarwara TPP	11163	1600	6.98	4.09
2017	Mauda TPS II	8278	1320	6.27	2.92
2019	Solapur TPS	12500	1320	9.47	5.06
2017	Sembcorp TPP	11250	1320	8.52	4.54
2021	Bhadradri Therm	9000	1080	8.33	2.84
2017	Yermarus TPP	12915	1600	8.07	3.43
2018	Kudgi STPP	16935	2400	7.06	5.11
2021	Neyveli New TPI	9750	1000	9.75	4.40
2021	Barauni TPS 8&	6303	500	12.61	2.77
2019	Nabinagar TPP	8100	750	10.80	2.15
2021	Nabinagar STPP	10792	1320	8.18	2.01
2019	Boingaigon TPP	8292	750	11.06	2.97

Building new coal is a tremendous drain on consumers and fiscal resources

The 300,000 Cr India wasted on coal capex in 2017-2021 could have instead built:



1.5 million Affordable homes	133,000 MWh storage	60,000 MW solar	40,000 MW solar	Piped water for every home in India

Further reinforces that financing is not a constraint on RE.

One Solution: RE + storage

- Sample plant: 100 MW Firm Power
  - 400 MW solar @ 3.9 Cr/MW, 21% CUF
  - 200 MW wind @ 6.0 Cr/MW, 30% CUF
  - 300 MWh (3 hour) battery @ 1.9 Cr/MWh, 85% RTE, 4% annual augmentation
  - Not making any assumptions around price decreases or technology improvements
- Blended Price of Rs. 3.51 (assuming "firm" 100 MW @ 4.09/kWh and excess sold at Rs. 2.88/kWh). 92% availability (vs. 74% for coal).
- There are other ways to optimize further (to be discussed later)
  - If you look at India's peak it is 2-3 hours. So it would make more sense to have an energy + peaking, rather than "RTC"
  - GUVNL Tranche XV tender (6 hour peak), Chattisgarh SECI Solar-storage tender (3 hour peak), MSEDCL 250 MW RfS and SECI RTC-III are also steps in the right direction.

There are many good examples in India itself

- Chattisgarh. 100 MW solar with 40 MW/120 MWh. Direct contracting rather than PPA means higher upfront cost, but potentially cheaper in the long run
- GUVNL, 500 MW Hybrid Tender (excellent design. Reliability requirements is 80% which is higher than coal, but still lower than what is possible)
- GUVNL, Standalone BESS tender (500 MW/1000 MWh). There is value in separating energy and capacity planning
- MSEDCL, 250 MW Hybrid Tender. Technology agnostic-well designed so pumped hydro, BESS, etc can participate
- Various SECI RTC tenders have been a good gesture, but the technical parameters tend to favour energy rather than firm capacity, one of the reasons they are less attractive to DISCOMs. It is important to get this right!
- KSEB stand-alone storage system
- SECI 500 MW/1000 MWh standalone storage tender**

If properly-sized, RE + storage is both economic and reliable

								Peak Price		
#	Scenario	Solar (MW)	Wind (MW)	Storage (MWh)	Availability	CUF	Blended Price	Excess @ 2.88	Excess @ 2.29	Excess @ 0.0
1	Match Coal Plant CUF	300	125	0	74%	124%	2.97	3.03	3.43	4.97
2	Match Coal + Balancing	300	125	50	77%	124%	3.13	3.28	3.63	5.02
3	Oversize	400	200	0	82%	179%	2.98	3.09	3.78	6.47
4	Oversize + 1 Hr storage	400	200	100	87%	179%	3.19	3.52	4.13	5.91
5	Oversize + Peaking	400	200	250	92%	179%	3.51	4.10	4.65	6.79
6	Oversize + 4 Hr Storage	400	200	400	95%	179%	3.83	4.64	5.14	7.10
7	Oversize + 6 Hr storage	400	200	600	98%	179%	4.25	5.34	5.80	7.61
8	99% avail (overbuild)	500	220	600	99%	212%	4.04	5.33	5.99	8.53
9	99% avail (storage)	400	200	675	99%	179%	4.41	5.60	6.06	7.84

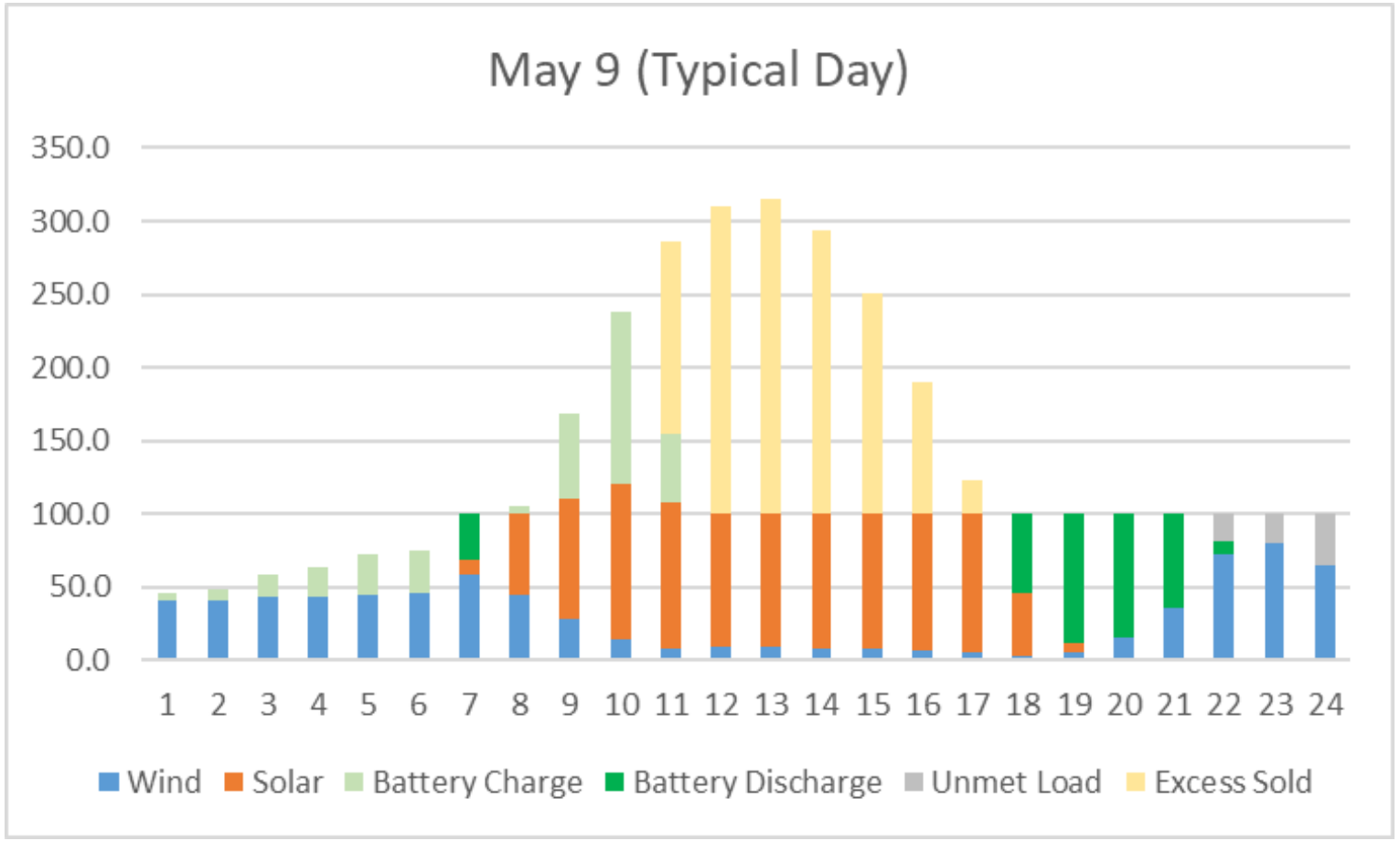
Options for 100 MW "firm" power supply from wind + solar + storage

In the near-medium term (pre-2030), there is plenty of surplus (thermal) power in the middle of the night, so peaking is the primary need for energy storage

For a 100% RE future, 6-12 hours of storage will be required

Note coal plant availability in India is 74%-we are already holding RE + storage to a higher standard!

What does RE + Storage look like?



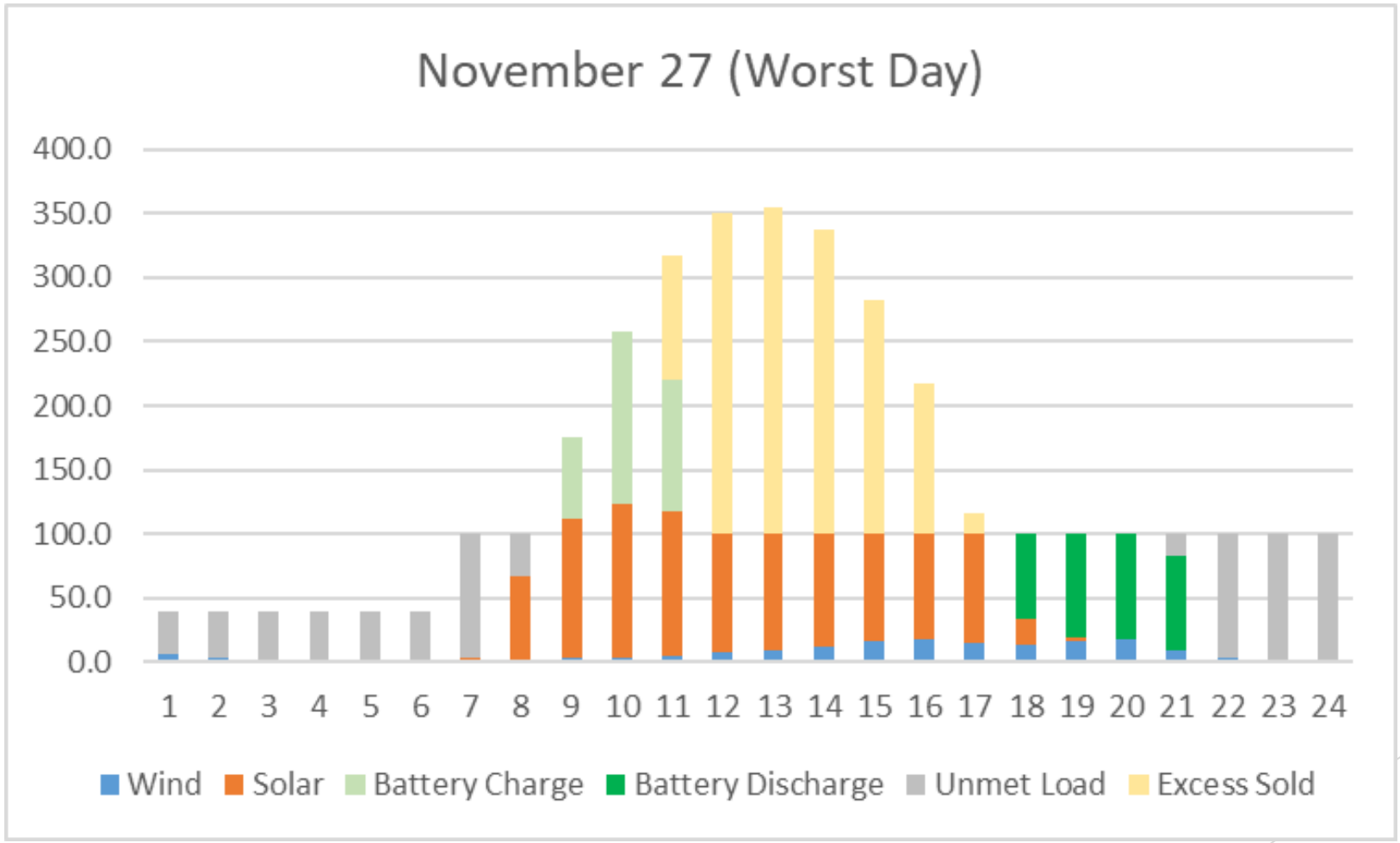
In India, wind and solar are decent complements

What sort of peaking resource to meet the small unmet need? DR? Biogas? Biomass? Overbuild RE + storage?

Median Day is 95% RE (Mean of 92% RE). 92% availability is much higher than coal availability of 74%

Mean generation is 169% of load- economics still work even if DISCOM pays just Rs. 2 for excess- well below VC of most coal plants

What does RE + Storage look like?



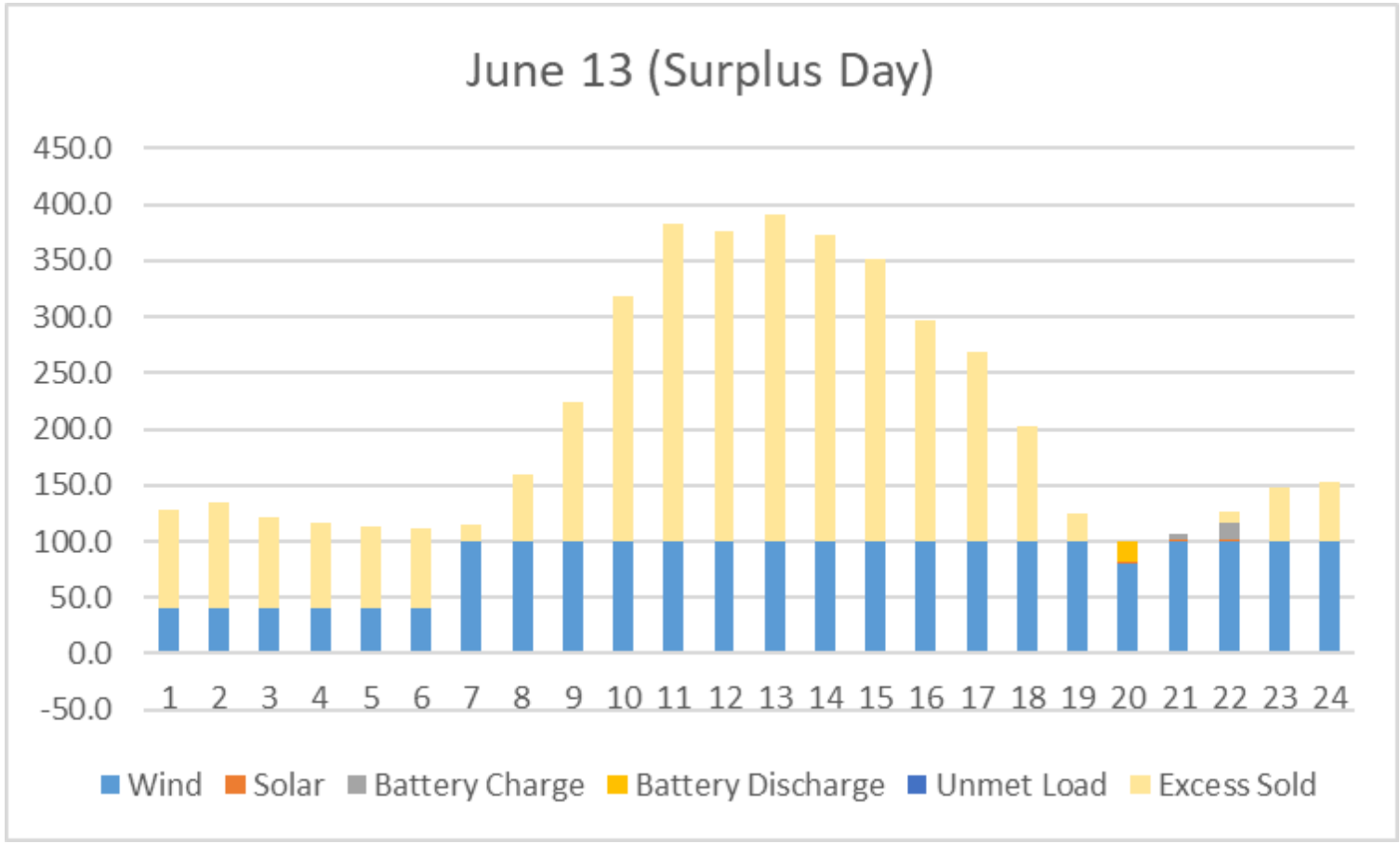
Note the worst day is due primarily to negligible wind

In the long-term, may need to overbuild solar/storage (currently expensive)

In the short-medium term, a DISCOM could likely buy cheaply from the market in off-peak hours

Building a coal plants for just 500 hours/year is extremely expensive! Many other capacity options are

What does RE + Storage look like?



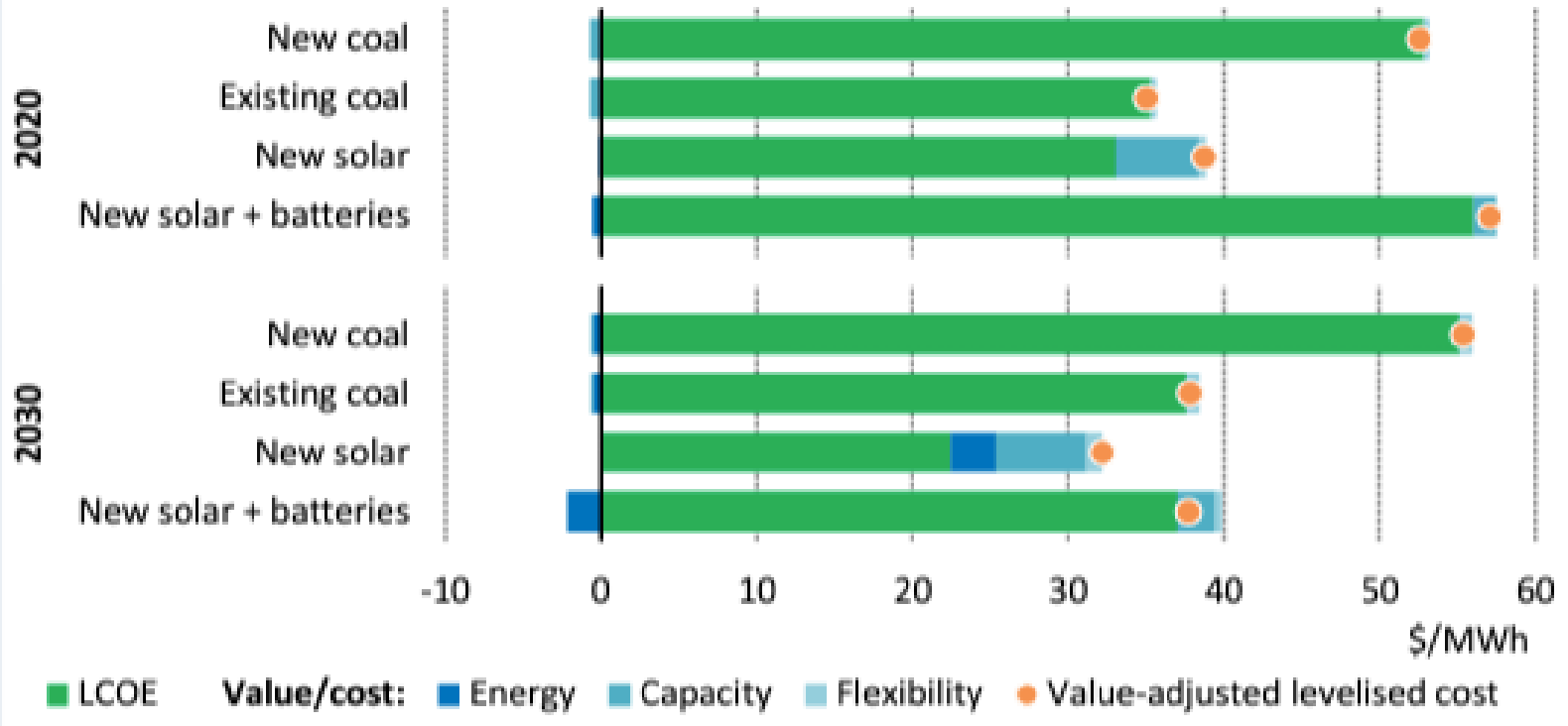
About 40% of days are met with 100% RE (though this is an extreme day, the average day would have 69% excess). For now, energy short DISCOMs should be happy to buy at Rs. 2/kWh

In the long-term excess may be curtailed (hurts blended price, but still cheaper than coal)

What else can absorb this excess? Green Hydrogen? Agricultural load shifting? Smart EV charging? Pre-cooling building or thermal storage? RE-derived marine or aviation fuels?

The cost advantage of RE will continue to grow, and start to justify retiring existing coal

Figure 3.6 ▷ **Value-adjusted levelised cost of coal and new solar, with or without batteries, in India in the STEPS, 2020 and 2030**



Should we retire coal today?

- Tata Mundra (Rs. 6.05/unit) and Adani Mundra (Rs. 6.52-7.10/unit)
  - Due to recent coal crisis, seeking increase to Rs. 9.11/unit
- Even at the old rates, and even assuming the FC (Rs. 0.9/unit) is paid for the duration of the contract (no negotiated savings), DISCOMs could save ~Rs 10,500 Cr/year by building Solar + Wind + storage to replace these plants
- However, this would require building ~ 25-30 GW of wind/solar, plus 8.6 GW/25 GWh of storage on top of the 35 GW/year required for demand growth
- We first need to significantly ramp up RE deployment to meet demand growth, then build additional RE to start retiring uneconomic coal

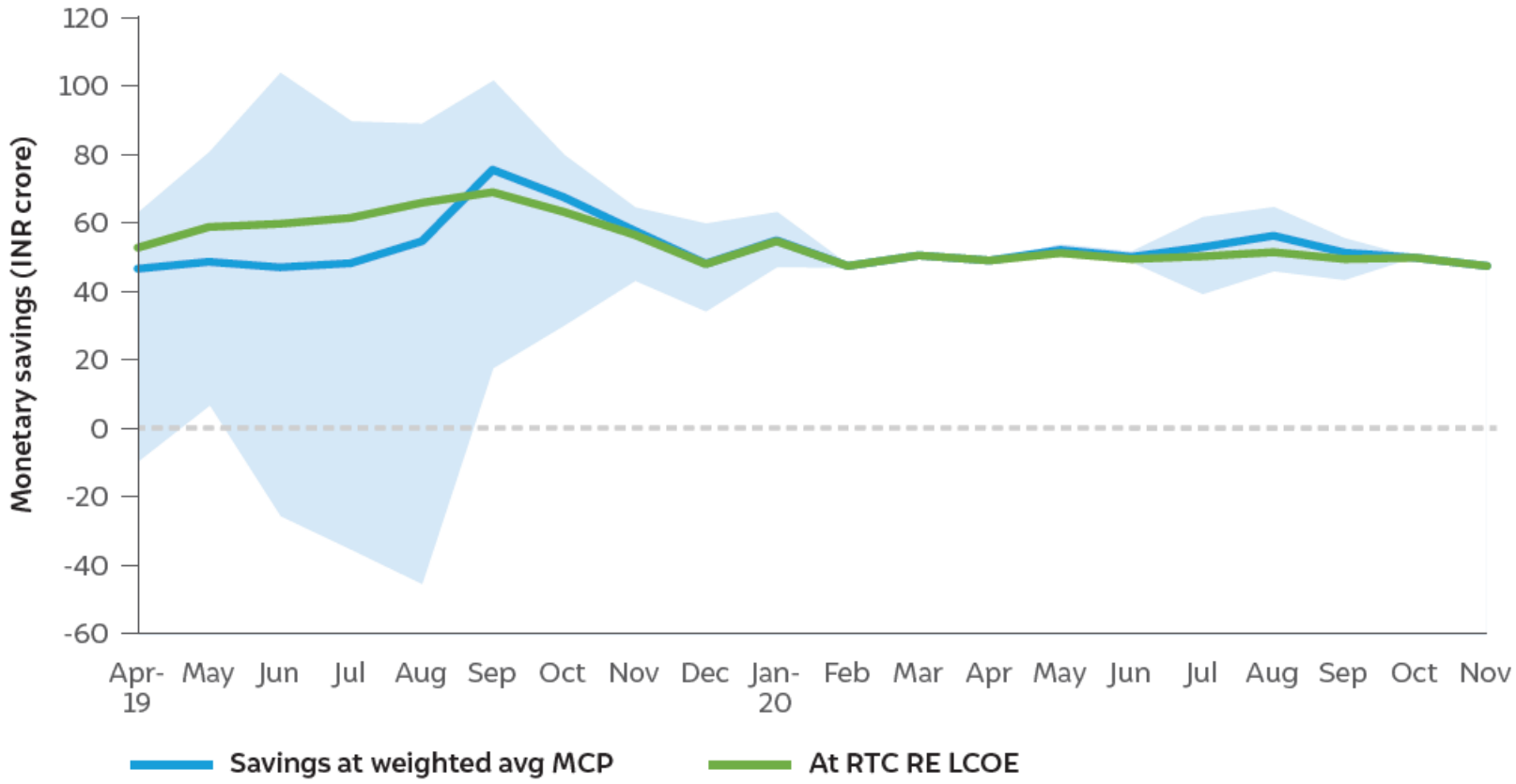
Tamil Nadu Could save ~4300 Cr by converting old Coal plants to Solar + Storage + Syncon

PLANT SPECIFIC SUMMARY TABLES (COSTS & BENEFITS) (INR CR)					
		Benefits (INR CR)			
Plant	Decommissioning Costs	SPV + BESS (Ash Pond only)	SPV + BESS + SynCon (Ash Pond only)	Entire Plant Area	As % of Capex (SPV + BESS + SynCon)*
Tuticorin Stage I, II & III (1050 MW)	380	765	1164	1266	92%
Mettur I & II (840 MW)	249	435	754	815	372%
North Chennai Stage I (630 MW)	200	368	607	657	168%
Neyveli II Stage I & II (1470 MW)	447	862	1421	1563	210%

Dr. Abhinav Jindal and Dr. Gireesh Shrimali, Climate Risk Horizons, “Financial benefits of repurposing Tamil Nadu’s old coal plants

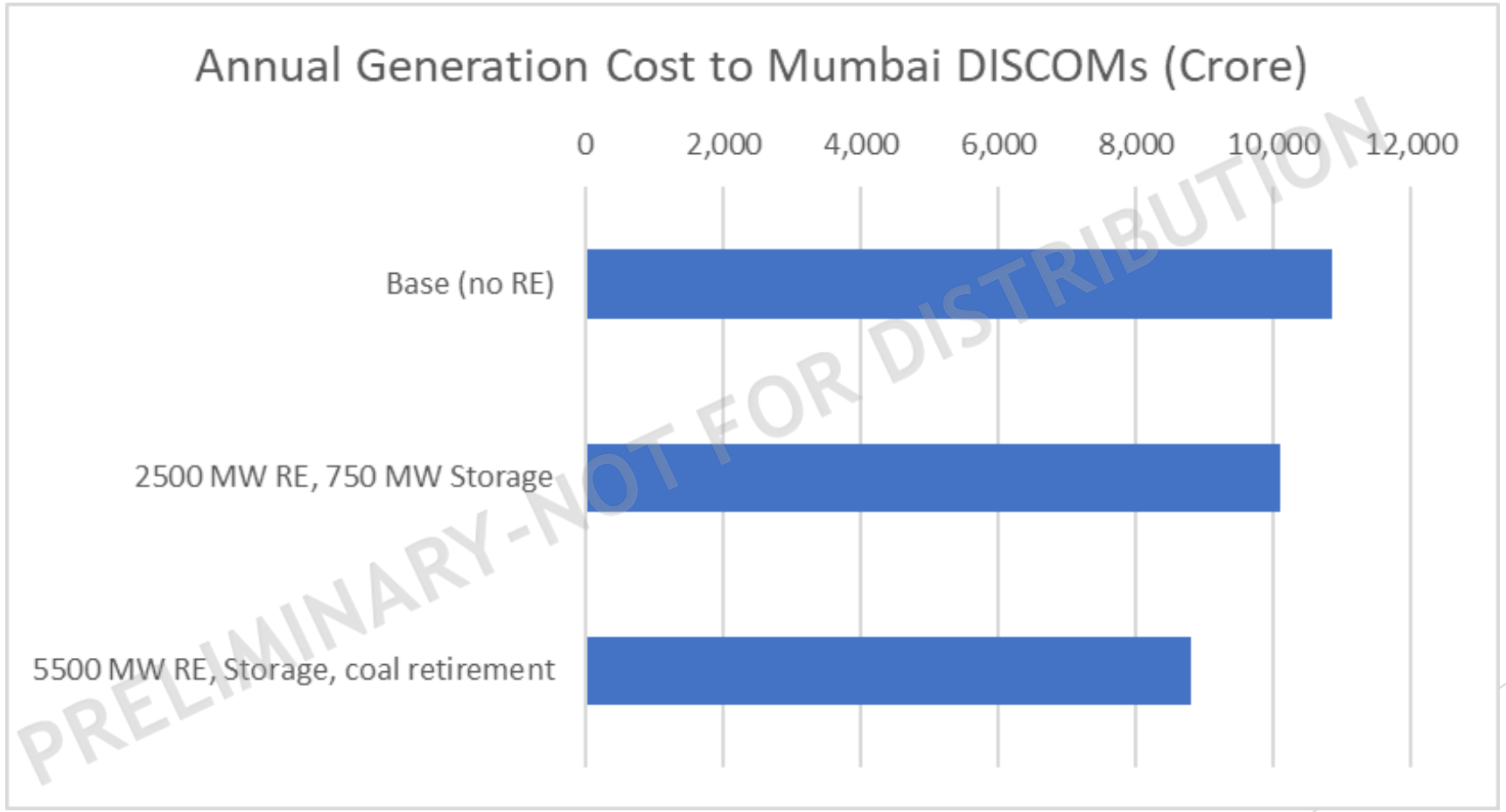
Delhi DISCOMs could save thousands of Crores by ending Dadri PPAs

Figure 5 Delhi's discoms could have saved INR 1,050 - 1,098 crore over 20 months



Dhruvak Aggarwal, Harsha V. Rao, and Disha Agarwal , CEEW and Shakti Sustainable Energy Foudnation "FinaHow can Discoms Optimise Power Procurement Costs

Mumbai could save ~2000 Cr/Year by switching from coal to RE



Note the storage would have to be located within Mumbai itself (eg. At the Trombay site) to provide system stability

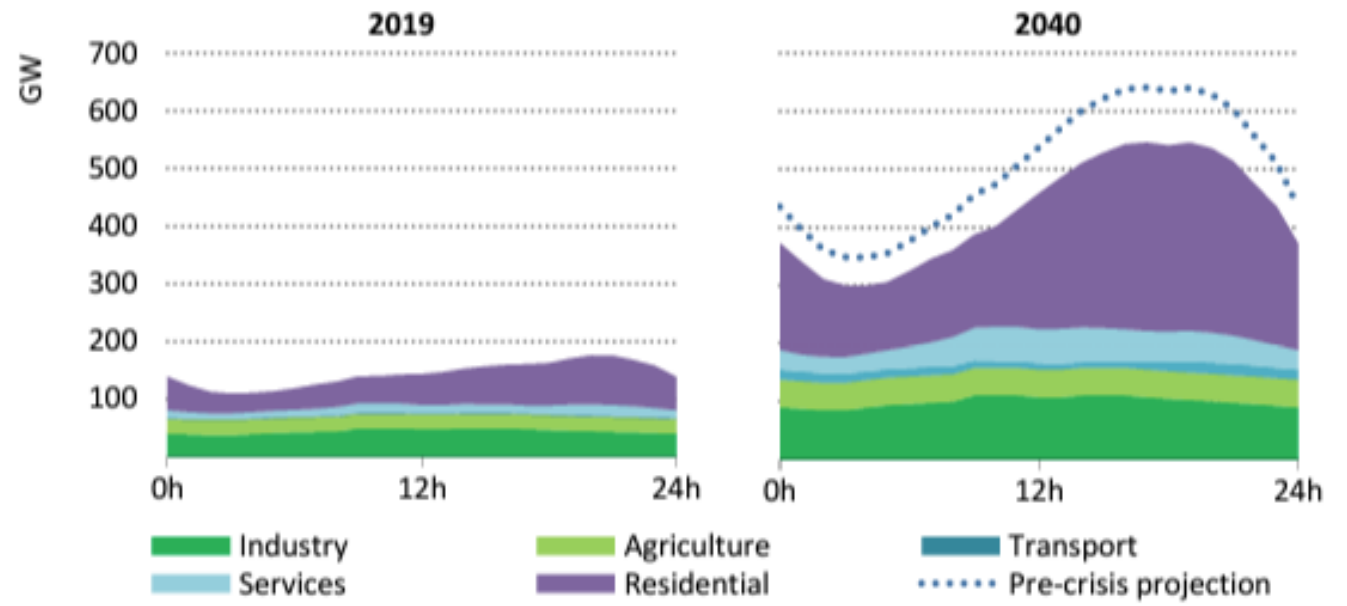
Battery is much faster-acting than coal so with a 750 MW storage instead of coal, system stability actually improves

India in 2040

All the previous slides have been based on current/existing prices, and therefore should be done today. The next set of slides is based on speculation/future. I do not like prognosticating on the future, so should take them all with a grain of salt

India in 2040

Figure 3.3 ▷ Daily electricity demand in India in 2019 and 2040 in the STEPS



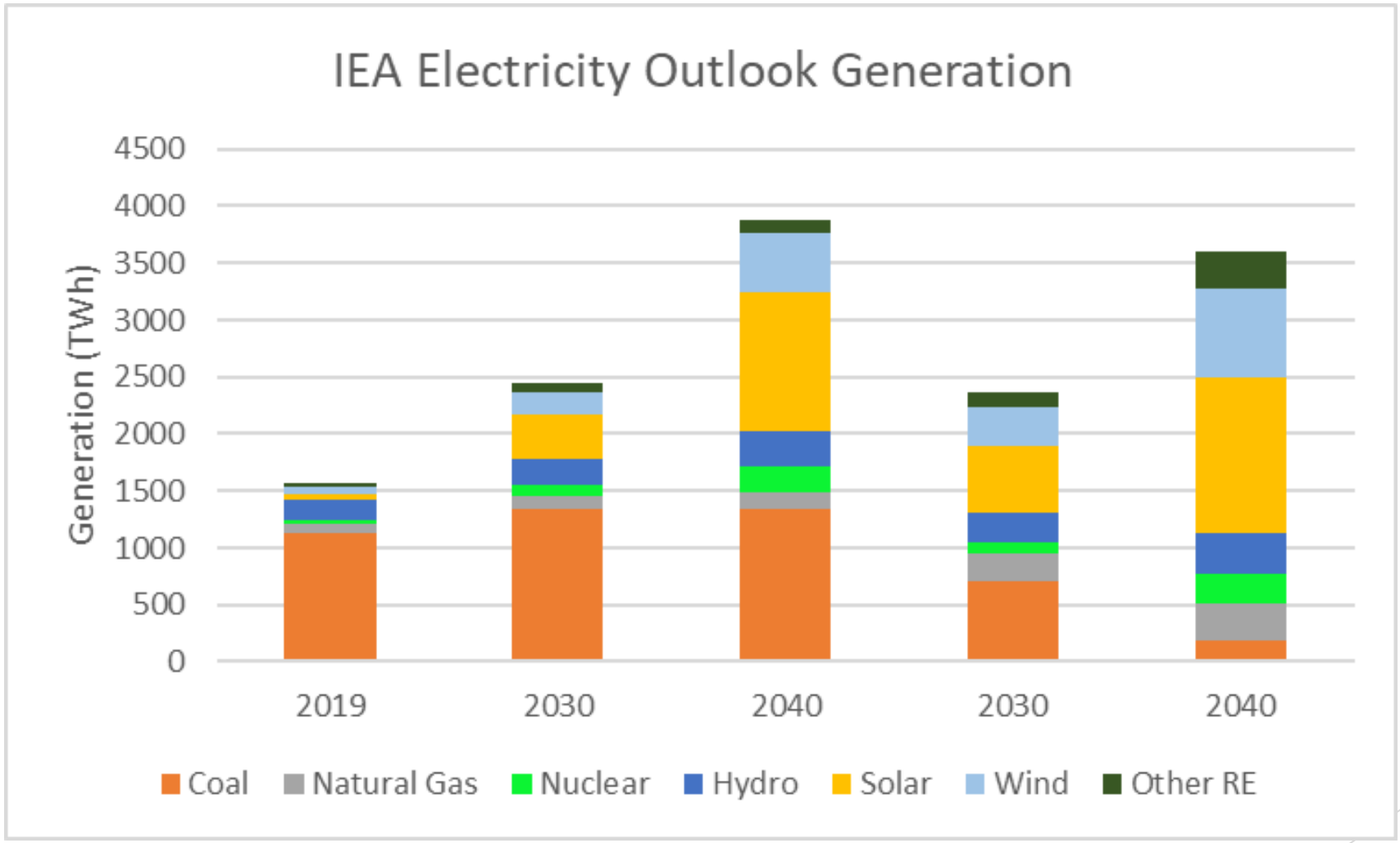
More than half a billion air conditioners and fans are purchased by 2040 in the STEPS, significantly raising the evening peak, although not as high as in pre-crisis projections.

Can save 25 GW ($9-$15B in peaking capex) by investing in energy efficient ACs-but need to start today

India has a Green Building Code, but it is not mandated/enforced

Incentive mismatch for rooftop solar, insulation, energy efficient ACs, etc. Tenant (residential, commercial, institutional, etc.) pays electricity bill (opex), but builder pays for construction (capex). Need intervention/innovation for alignment!

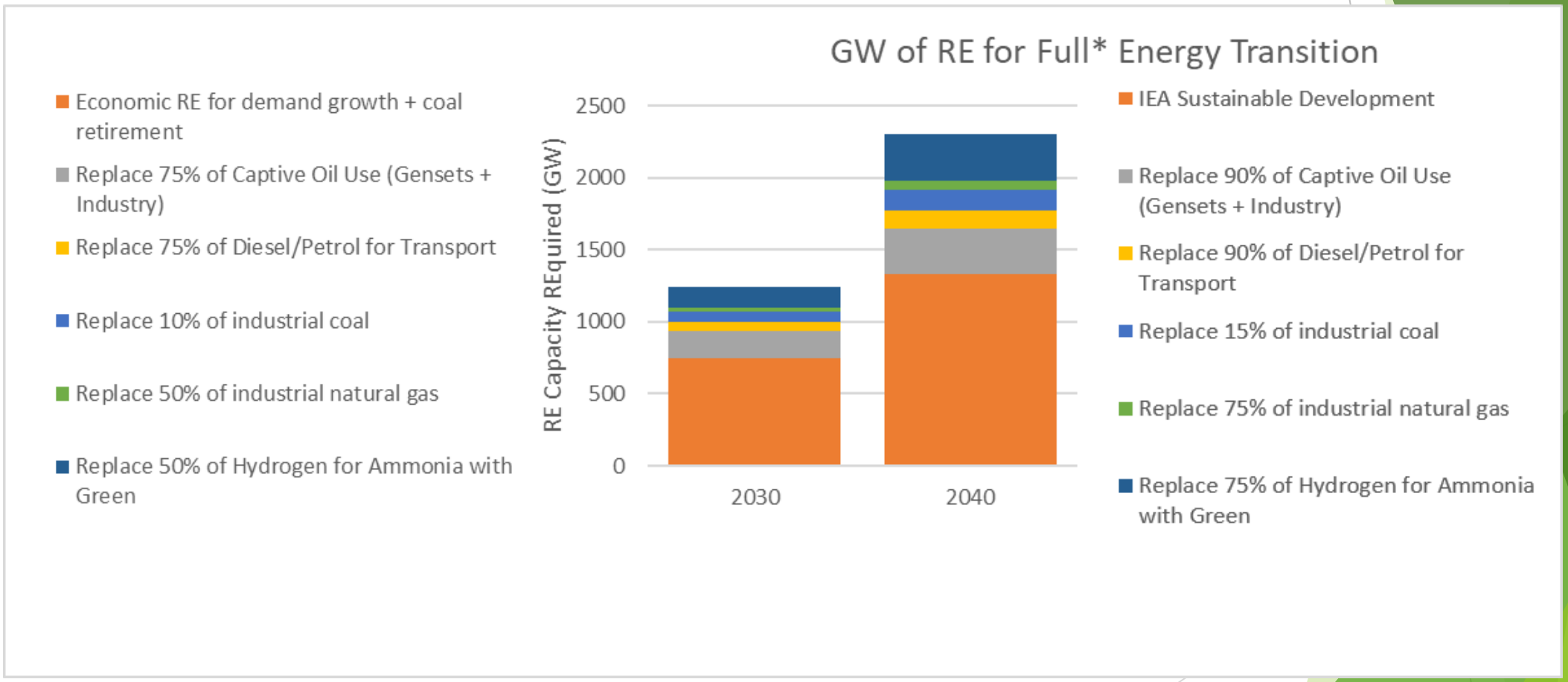
Need for renewables will continue to grow



In the SDS (Sustainable Development Scenario), RE will need to rise from 641 GW in 2030 to 1334 GW in 2040

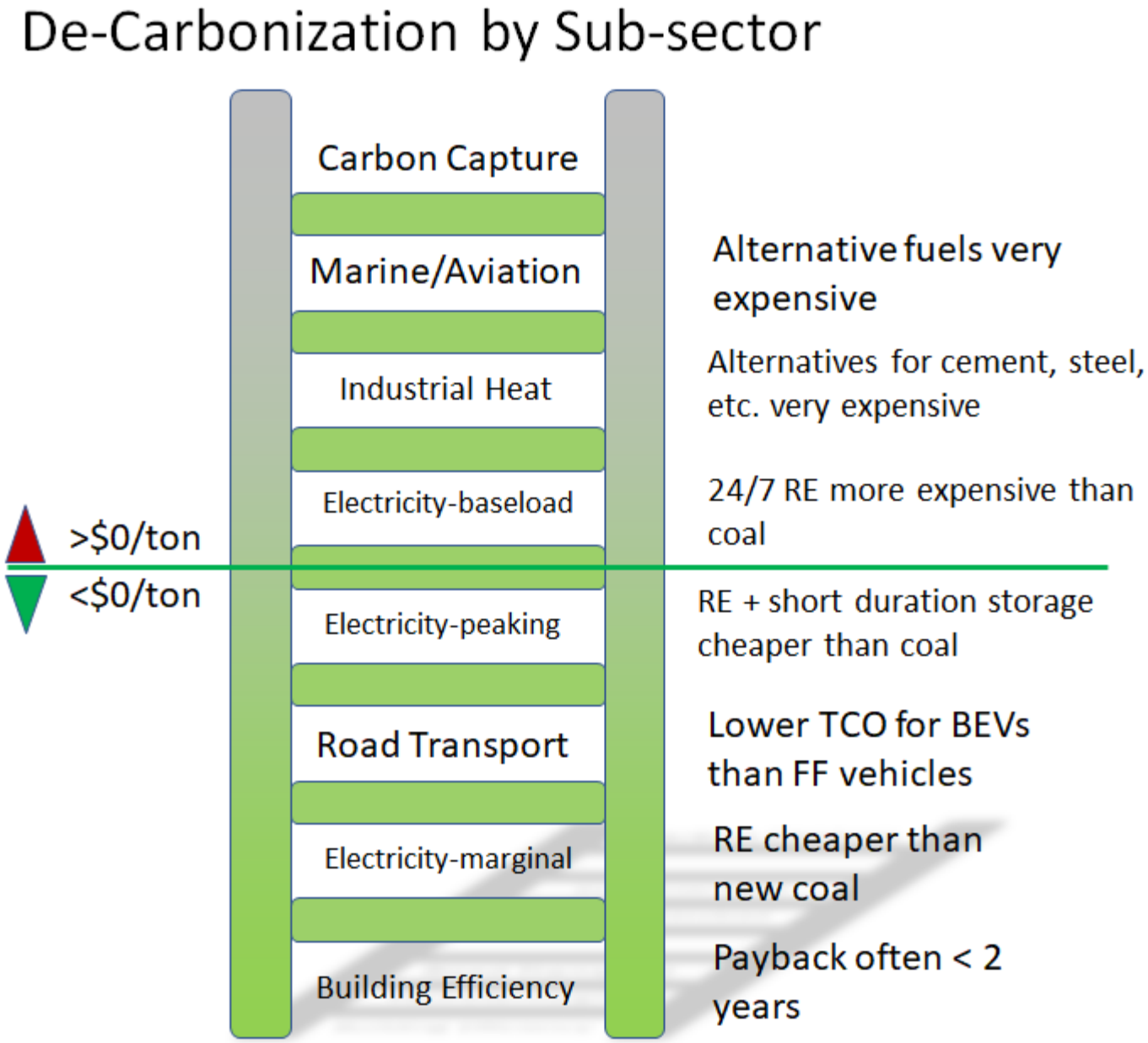
In SDS coal will peak in the 20s and be 40% lower than in 2019 by 2030

Beyond 2030: Renewables in Other sectors

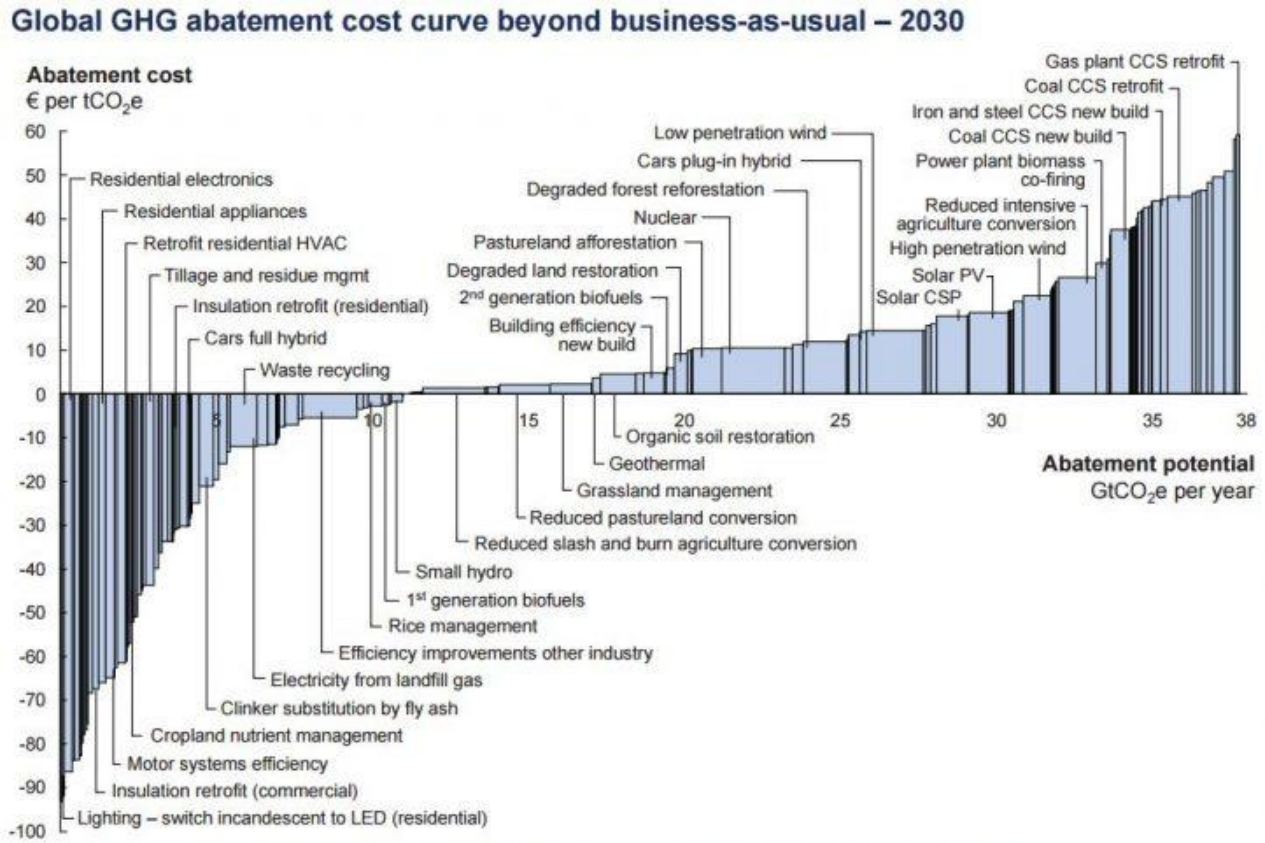


Very crude estimates. Note (unlike w/electricity) not all are economic

What should we prioritize today?



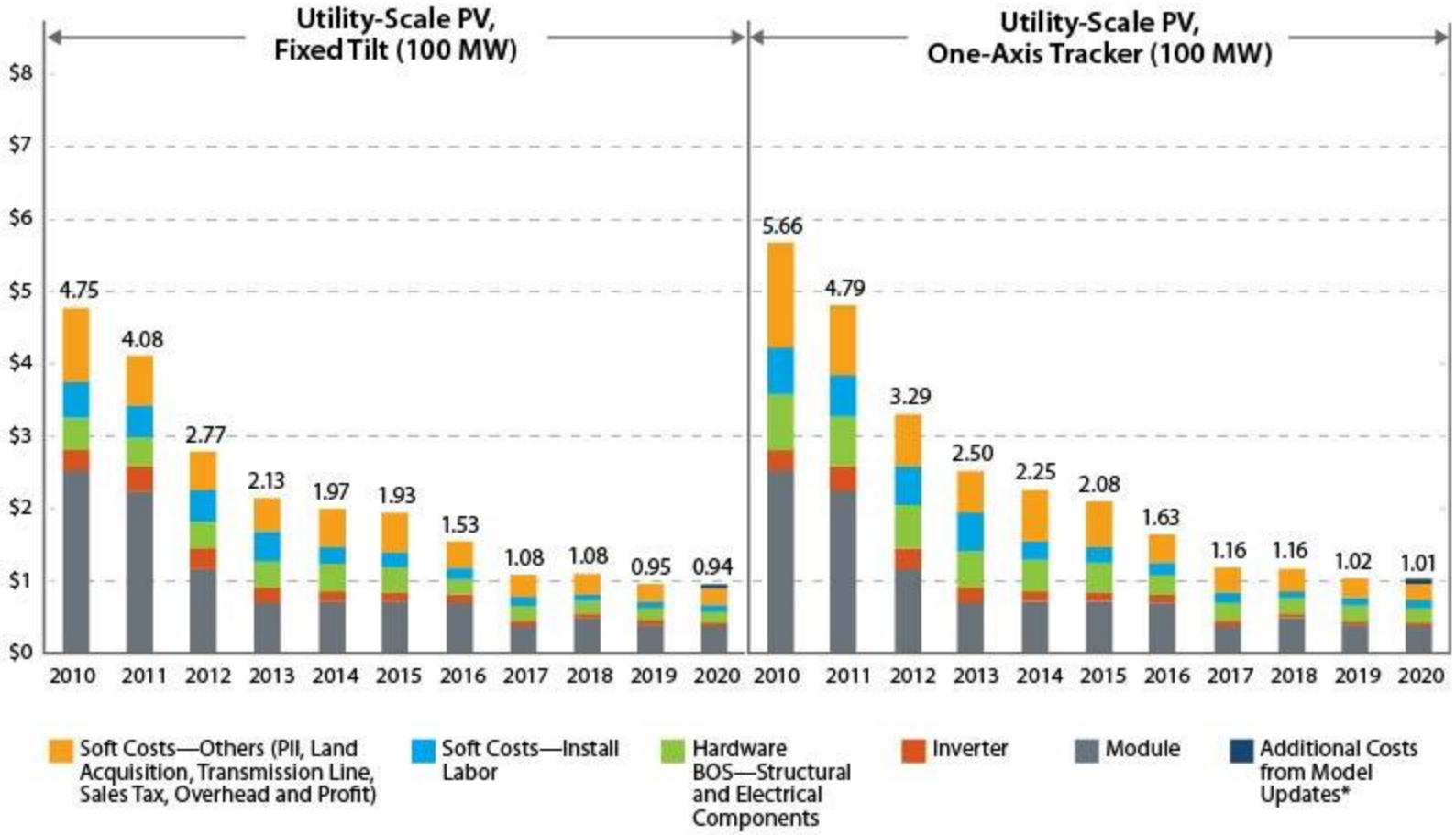
An example of a European carbon abatement curve



As far as I know, a nuanced analysis of this has not been done for India, but we should prioritize

1) Negative cost options (DSM, Green Building codes, no new coal)
2) Marginal cost (replace high-cost coal, electric vehicles
3) High cost options (eg. Green Hydrogen, Biomass for cement)

SOLAR PRICE Projections



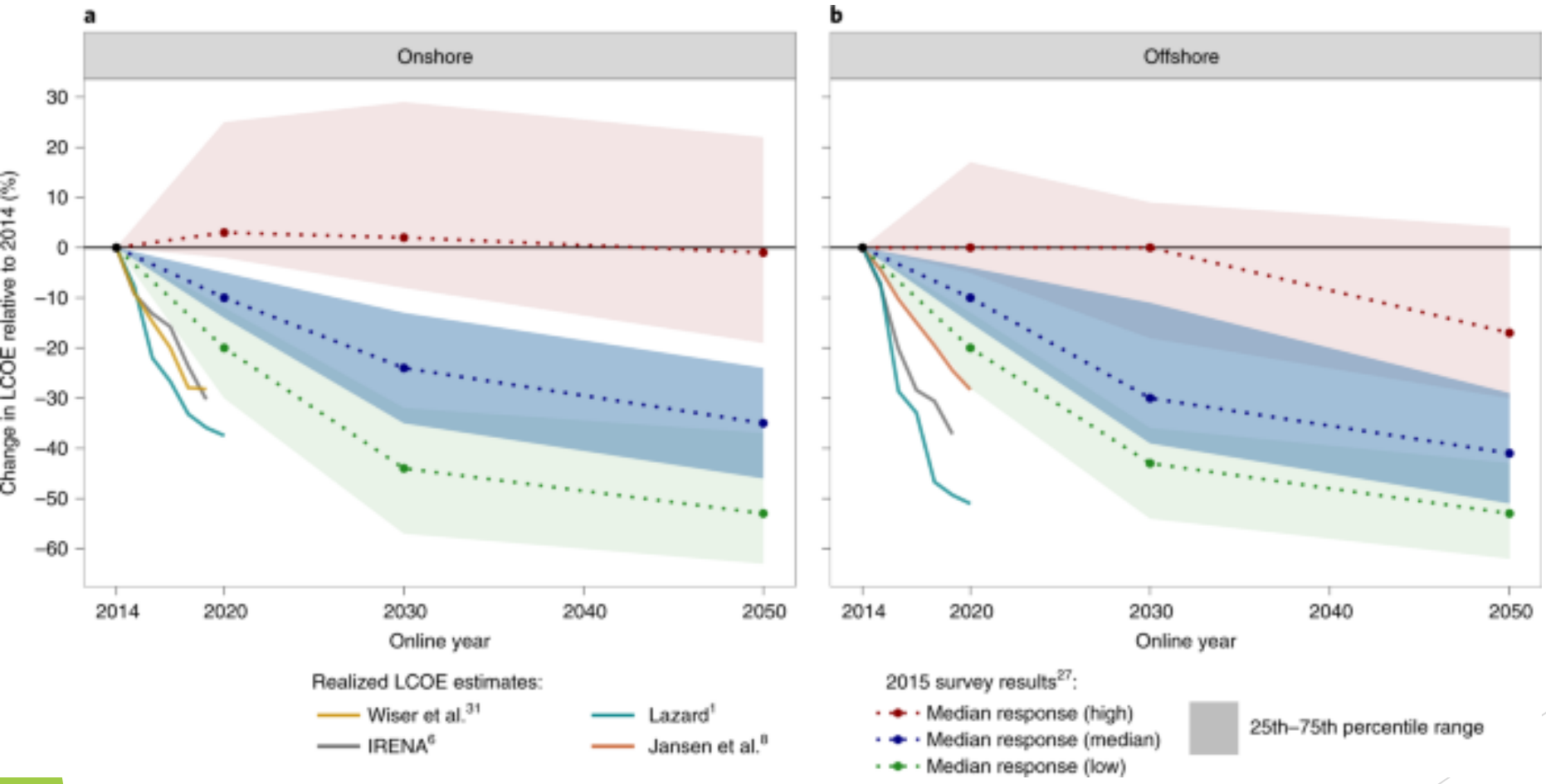
In India, current installed cost might be 3.9 Cr/MW

By 2030, this could drop to 2.6 Cr/MW

By 2050, this could drop to 1.2 Cr/MW
(IRENA)

Note that modules are less than half the installed cost, so further gains will need to come from reducing inverter and soft costs

Wind price Projections

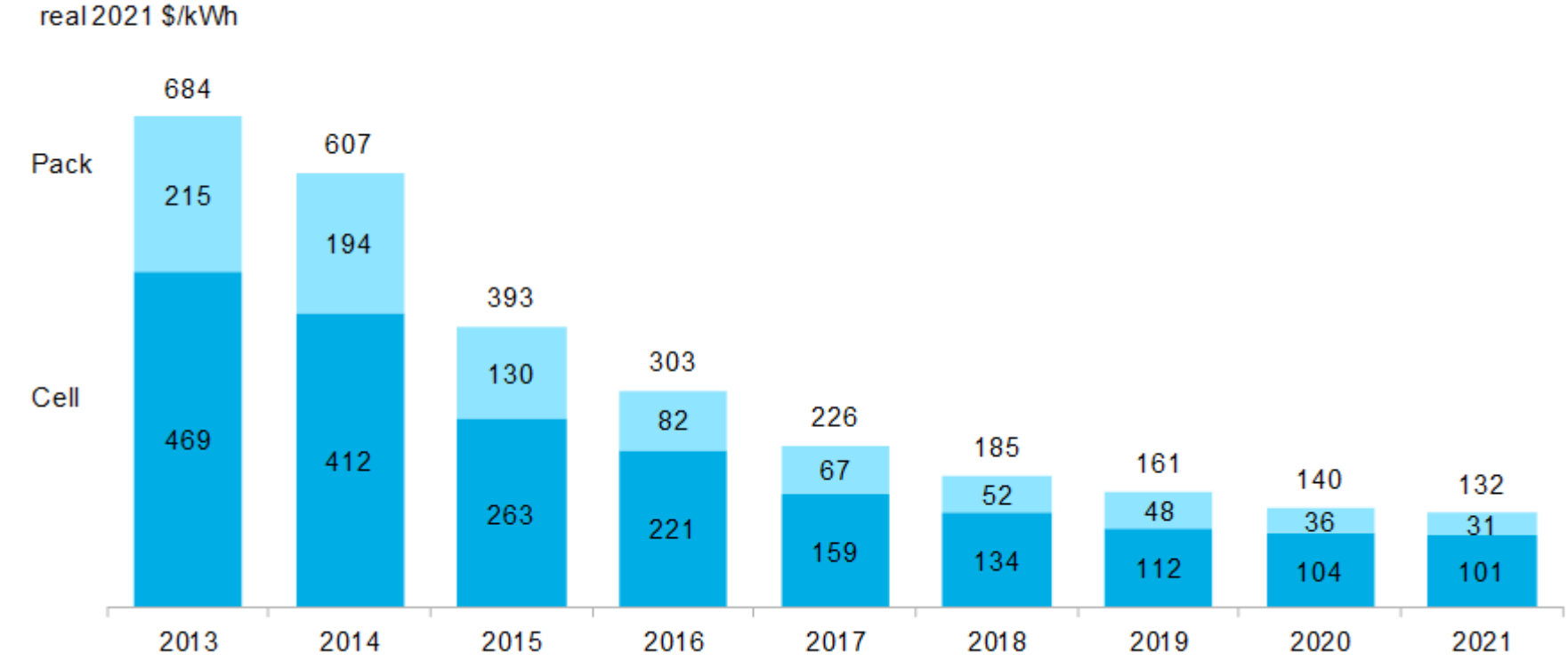


Higher hub heights can drive higher CUF, so even if cost/MW is flat, cost/MWh will decline

Ramping up India's manufacturing ecosystem by increasing demand may also drive down costs

Battery price projections

Figure 1: Volume-weighted average pack and cell price split



Source: BloombergNEF.

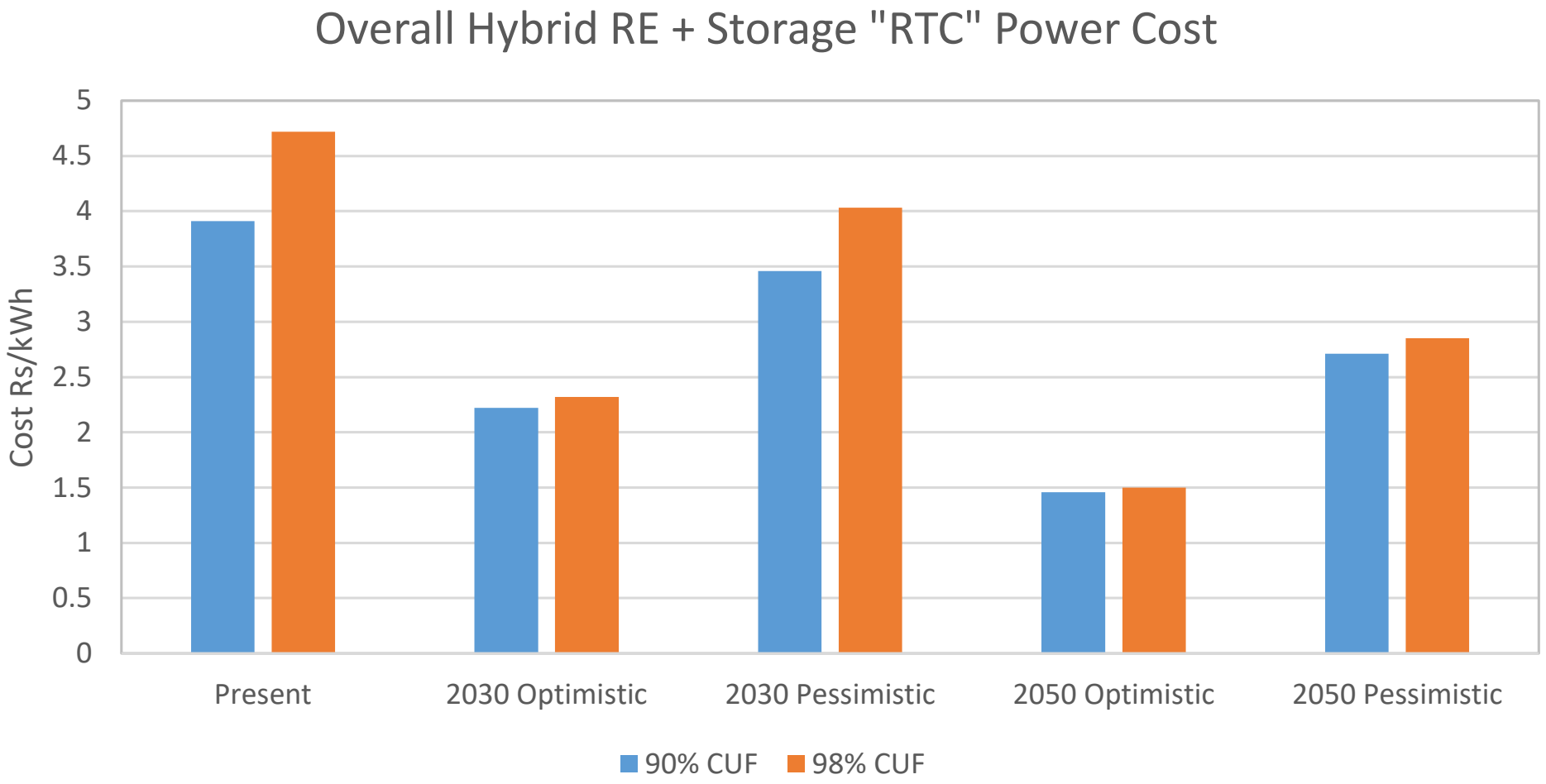
2025: $71/kWh
2030: $58/kWh
2050: $25/kWh?

At some point, we run into the underlying material costs (Lithium, cobalt, nickel)

On the other hand, by 2050, alternatives (eg. Iron-Air, Sodium, Compressed Air, thermal storage, etc.) may be viable

Installed Costs tend to be higher (eg. $250-$300/kWh, depending on system size and C ratio)

Bringing it all together: impact on LCOE



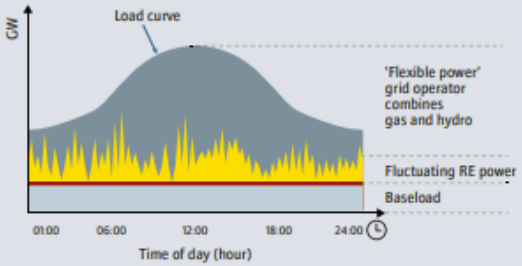
Even in the most pessimistic scenario, there will be effectively no existing coal plants left with a competitive VC in 2050, even ignoring capex

In an optimistic scenario, many existing coal plants would be uncompetitive from a VC perspective by 2030

India in 2050

India in 2050: need a mindset shift to go from coal “Baseload” + RE to RE/Storage Led Power Grid

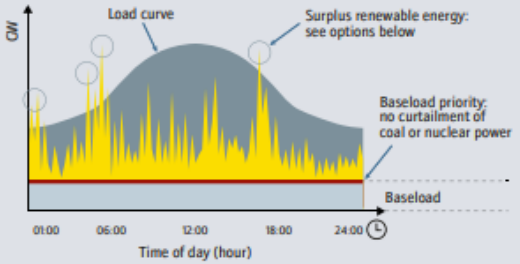
CURRENT SUPPLY SYSTEM:



- low shares of fluctuating renewable energy
- the ‘base load’ power is a solid bar at the bottom of the graph.
- renewable energy forms a ‘variable’ layer because sun and wind levels changes throughout the day.
- gas and hydro power can be switched on and off in response to demand. this combination is sustainable using weather forecasting and clever grid management.
- with this arrangement there is room for about 25 percent variable renewable energy.

TO COMBAT CLIMATE CHANGE MUCH MORE THAN 25% RENEWABLE ELECTRICITY IS NEEDED.

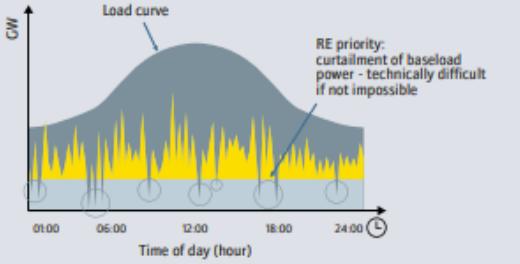
SUPPLY SYSTEM WITH MORE THAN 25 PERCENT FLUCTUATING RENEWABLE ENERGY: BASE LOAD PRIORITY



- this approach adds renewable energy but gives priority to base load
- as renewable energy supplies grow they will exceed the demand at some times of the day, creating surplus power.
- to a point, this can be overcome by storing power, moving power between areas, shifting demand during the day or shutting down the renewable generators at peak times.

THIS APPROACH DOES NOT WORK WHEN RENEWABLES EXCEED 50% OF THE MIX, AND CANNOT PROVIDE RENEWABLE ENERGY AS 90- 100% OF THE MIX.

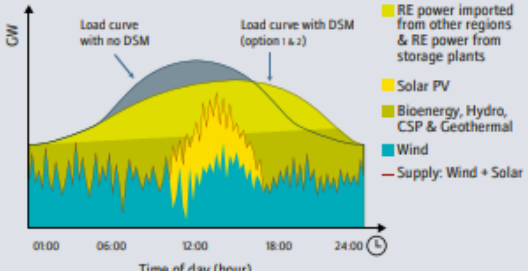
SUPPLY SYSTEM WITH MORE THAN 25 PERCENT FLUCTUATING RENEWABLE ENERGY – RE PRIORITY



- this approach adds renewables but gives priority to clean energy.
- if renewable energy is given priority to the grid, it “cuts into” the base load power.
- theoretically, nuclear and coal need to run at reduced capacity or be entirely turned off in peak supply times (very sunny or windy).
- there are technical and safety limitations to the speed, scale and frequency of changes in power output for nuclear and CCS coal plants.

TECHNICALLY DIFFICULT, NOT A SOLUTION.

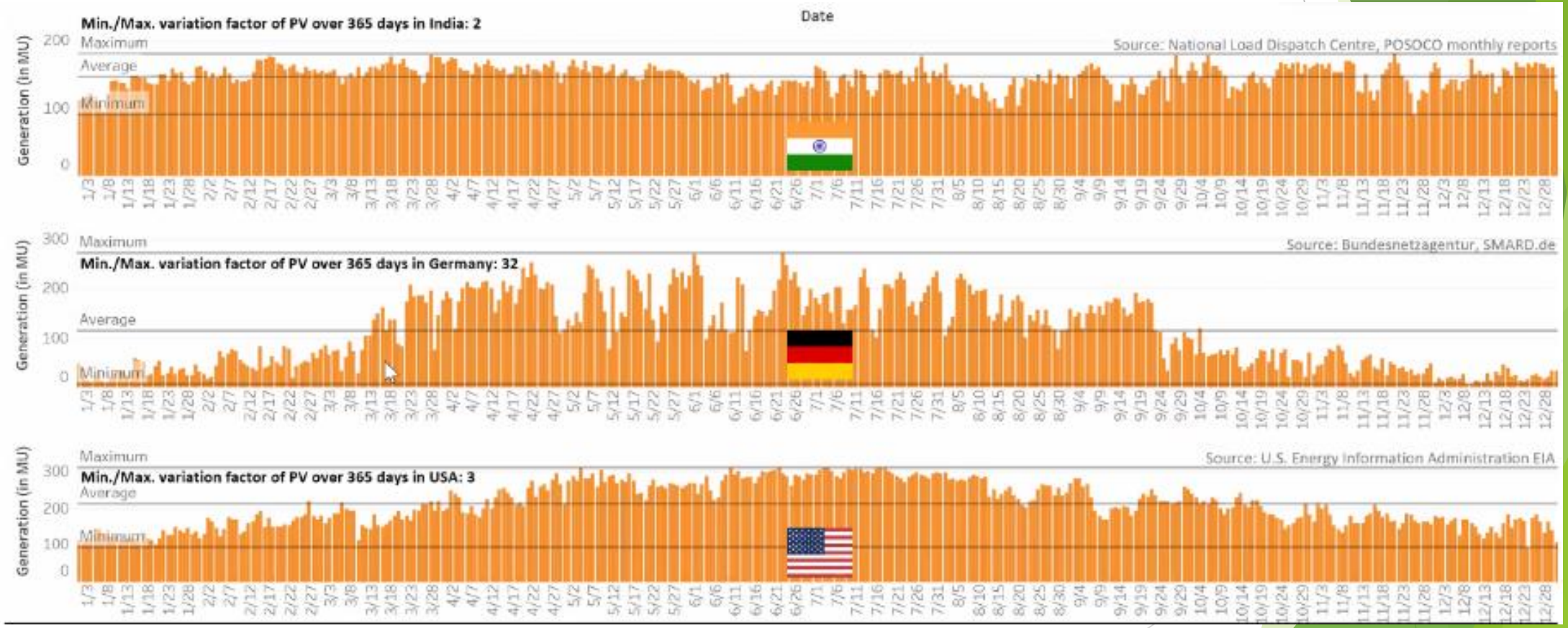
THE SOLUTION: AN OPTIMISED SYSTEM WITH OVER 90% RENEWABLE ENERGY SUPPLY



- a fully optimised grid, where 100 percent renewables operate with storage, transmission of electricity to other regions, demand management and curtailment only when required.
- demand management effectively moves the highest peak and ‘flattens out’ the curve of electricity use over a day.

WORKS.

LUCKILY INDIA has a diverse solar resource, so minimal need for seasonal/inter-day storage

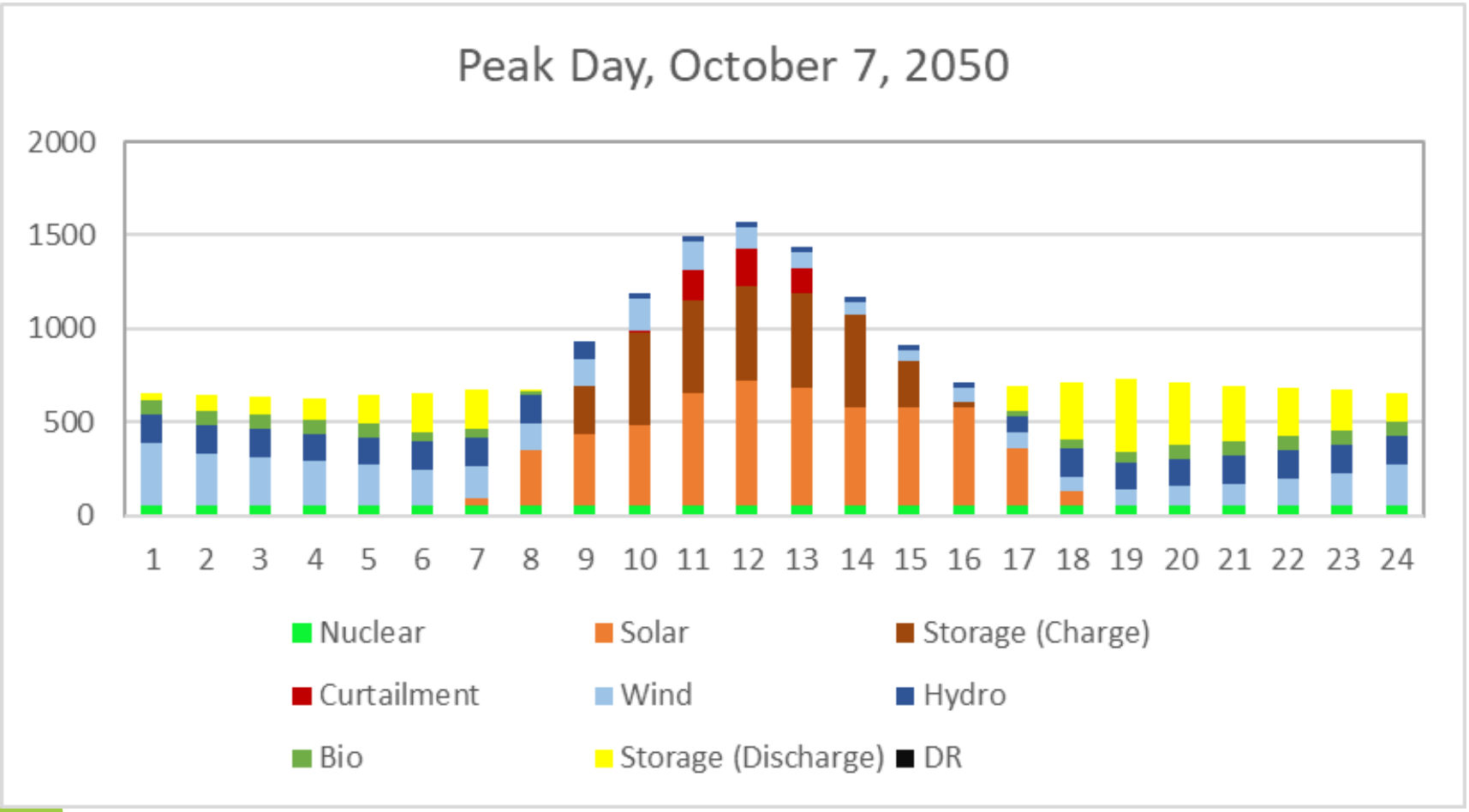


With solar + storage alone, an overbuild of 2x solar (with 18 hours storage) is all that is required. Of course can better optimize using wind, hydro, biomass, geothermal, etc.

RE100 electric grid in India (2050)

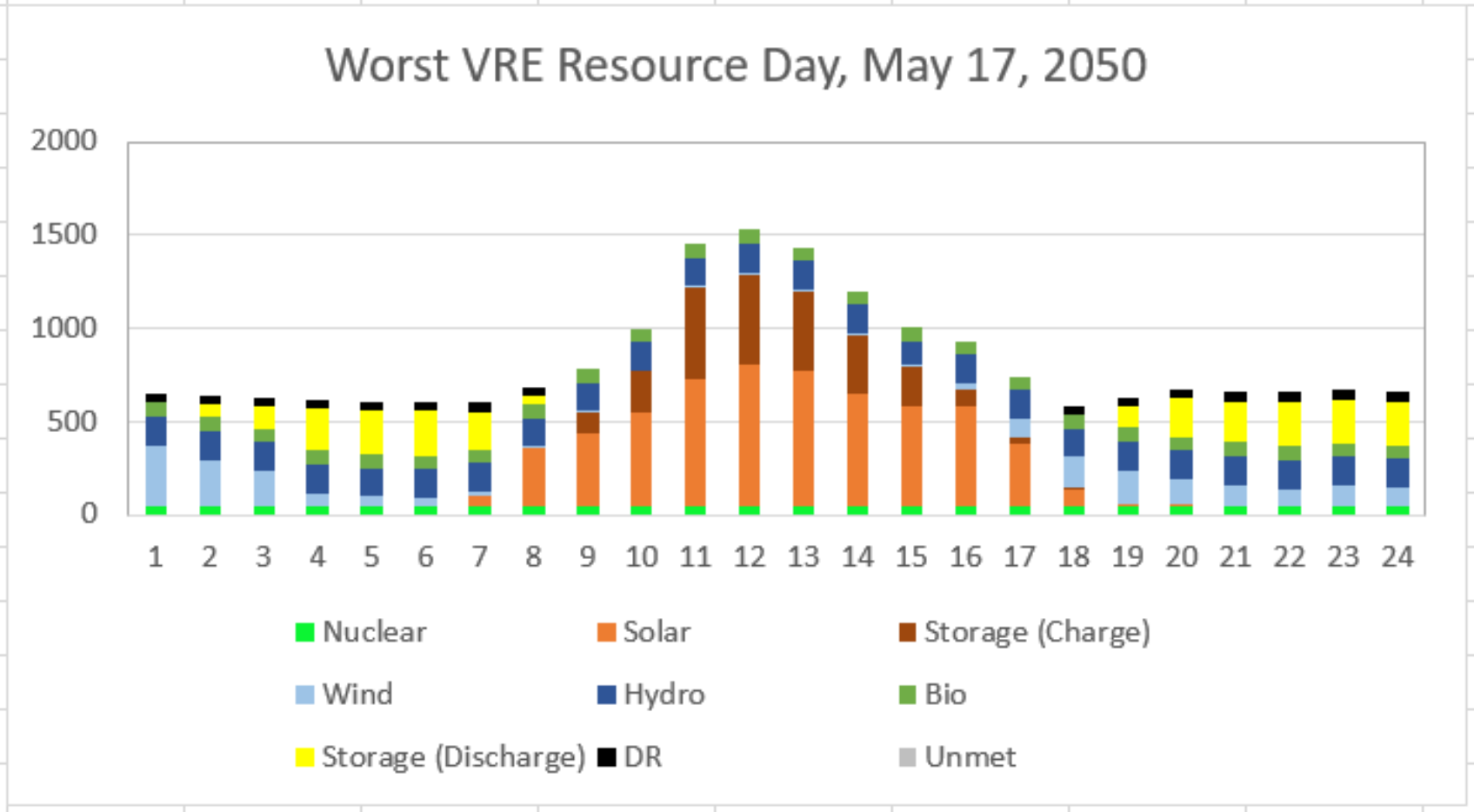
- 730 GW Peak (4% peak load growth from IEA SDS)
- 4800 TWh of Energy (3% energy growth from IEA SDS)
- Peak load profile from CEA 2030 (ignoring ag load shifting)
  - 1500 GW Solar
  - 700 GW Wind
  - 150 GW Hydro
  - 75 GW Bioenergy
  - 50 GW Nuclear
  - 400 GW of 5 hour storage
  - 100 GW of 12 hour storage
- ~10-20% of solar/wind is curtailed. Does it make sense to accept some curtailment, or use other forms of energy transformation (eg. Green Hydrogen) to couple to other sectors?

RE100 electric grid (2050)



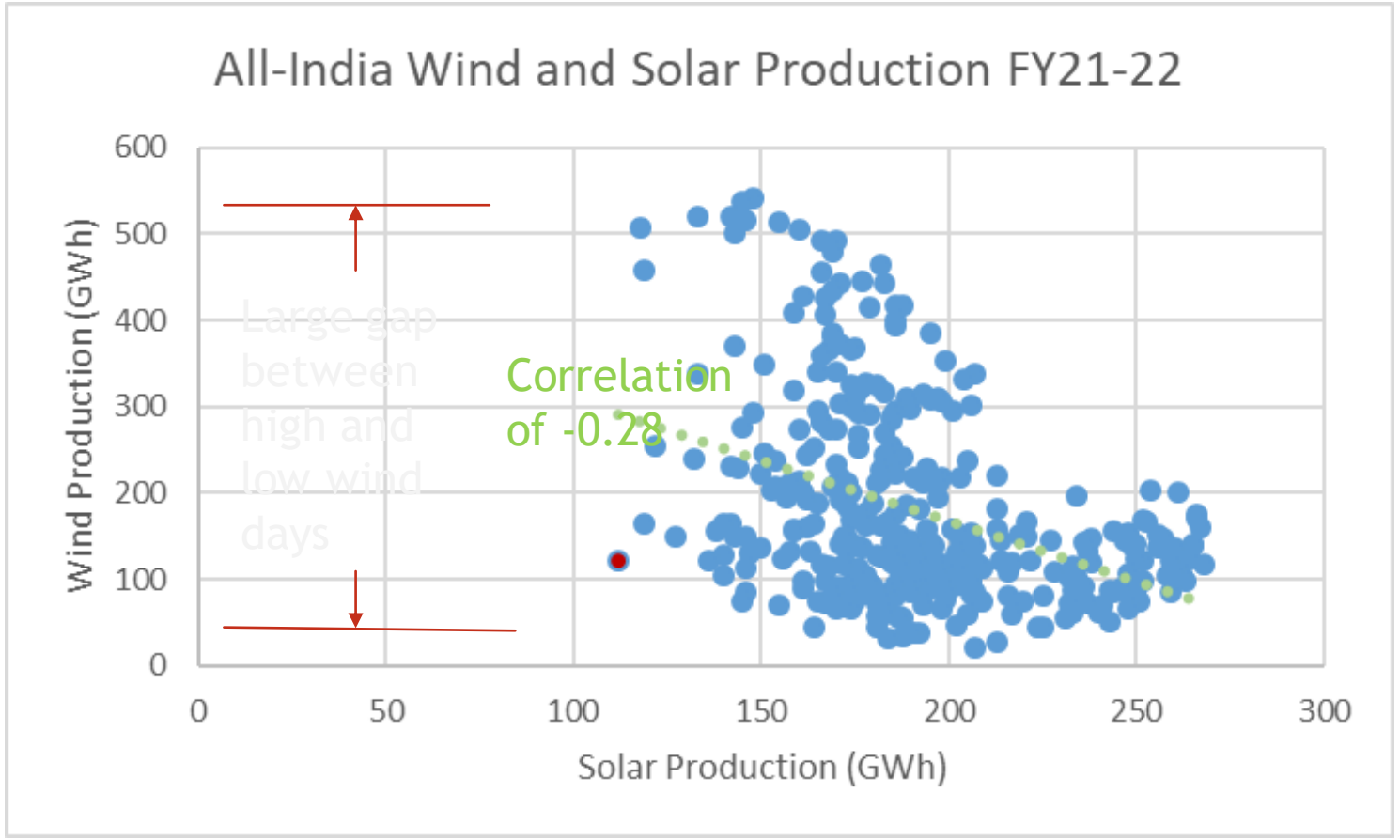
- Peak Demand easily met
- Bigger storage MW actually required for absorbing surplus solar, *not* meeting peak demand.
- Some solar curtailment, even on peak day! Presumably some ag/cooling/EV load shifting to absorb surplus solar in day, but some curtailment is okay-the blended price is still much cheaper than fossil fuels

RE100 electric grid (2050)



- In a 100% RE future, the lowest VRE day is actually more challenging to meet than the peak demand day
- Could be partially mitigated through geographic diversity/regional interconnections
- If DR is used, grid is more reliable than current grid. However there is an overbuild (cost) vs. underbuild (reliability) trade-off
- If energy storage costs continue to fall, 100% RE could be economic well before 2050

Wind and solar are natural complements in india



Low solar days tend to have more wind and vice-versa, so it makes sense to have both

However, solar is much more consistent, so if the grid is RE100, less overbuild/long-duration storage is required by focusing on solar rather than wind

Beyond 2050: What will remain to get to net zero

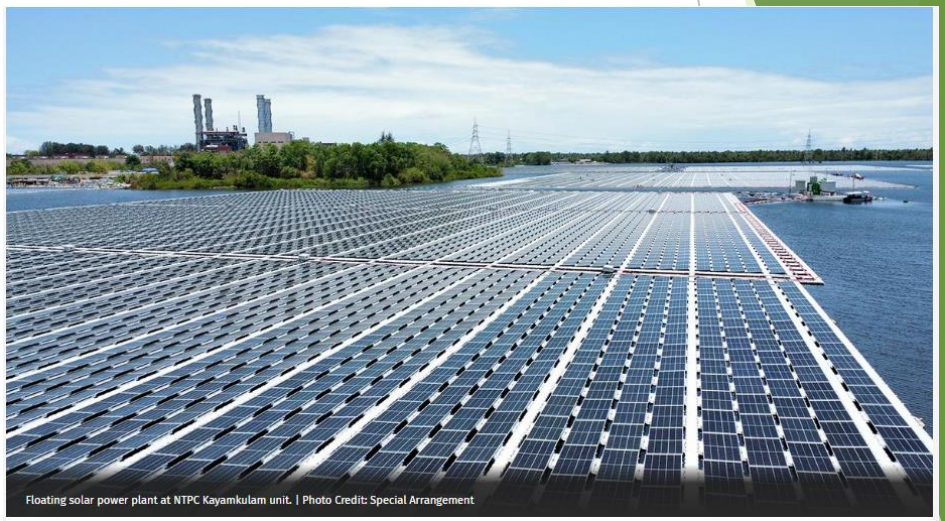
Already Economic by 2050	Potentially Economic by 2050	To be Solved post 2050
~100% RE Electric	Green Hydrogen for Ammonia/Chemicals	Agriculture emissions (esp. cattle-based methane)
~100% Electric road transport	Blending (eg. Bioethanol) for aviation/marine fuels	100% Sustainable Aviation/Marine Fuels
Industrial processes that can be electrified	High-temp heat for industrial processes (Biomass? GH?)	Use of (process) coking coal in steel, cement, etc. (CCS? GH-based

Path forward

INDIA Is Already a leader in some segments

Modhera, 24/7 Solar Town

Can be an replicated to help the 600M people worldwide who still lack electricity access



World's Largest Floating Solar (ex-China)

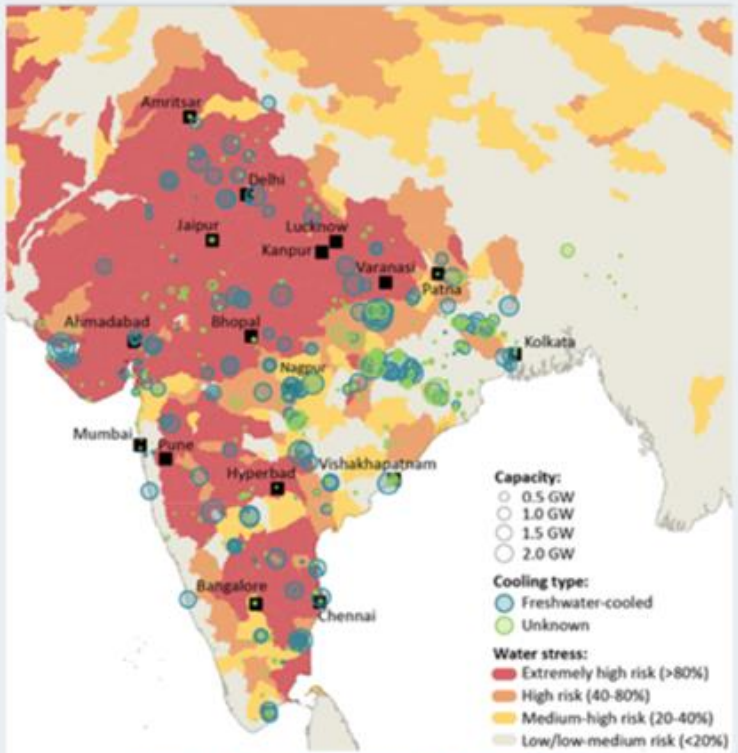
102 MW at NTPC Kanyamkulam unit.
At a very competitive 4.5 Cr/MW.
Ideal solution for land-poor countries like Bangladesh and Singapore

What else can be done?

- SECI has led the way with RTC Tenders, Solar + storage (Chattisgarh) tender, world's largest battery storage tender, etc.? However, the pace needs to be 3-4x
- Start-Ups like Log9, Exponent Energy, Clean Electric, Indi Energy doing world-leading research on battery tech. However, there tends to be limited support from India itself!
- Companies like PRESPL doing world-class work on biomass for industrial heat
- Greenko's work on off-river Pumped Storage Hydro, potentially making this more scalable (no longer geography-constrained)
- Hydrogen Fuel Cells (Ohmium, h2ePower)? Thorium reactors? Biogas?

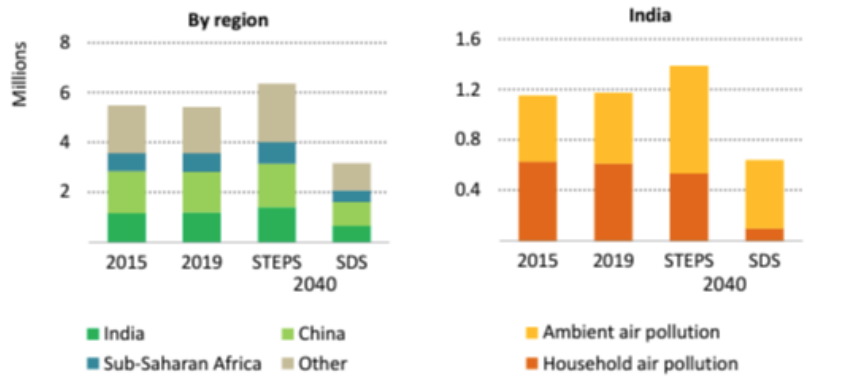
Solving these challenges have Spin-off benefits as well

Figure 3.32 ▷ Location of existing coal plants and baseline level of water stress in India



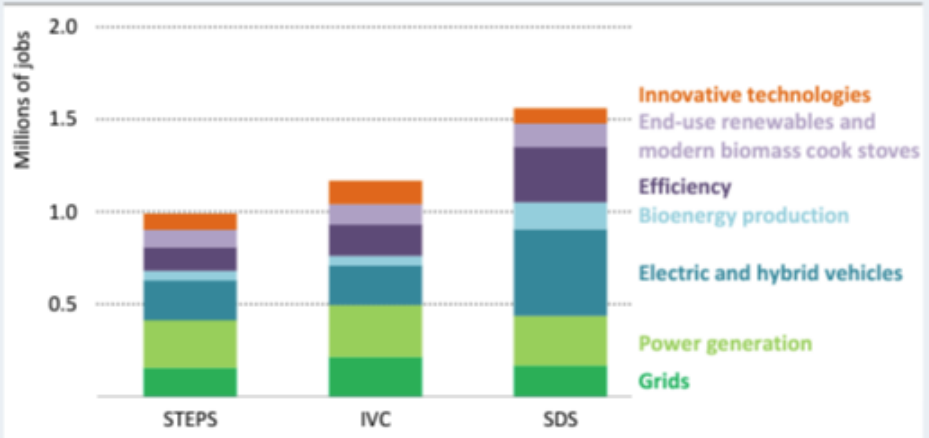
More than 50% of freshwater-cooled capacity lies in areas of high or very high water stress.

Figure 4.5 ▷ Premature deaths related to air pollution globally and in India



There were nearly 1.2 million premature deaths from air pollution in India in 2019. This number rises by 0.2 million to 2040 in the STEPS but falls by around 0.5 million in the SDS.

Figure 4.11 ▷ New full-time jobs added in India by 2030 by scenario and investment segment



Clean energy employment grows in all scenarios, especially in the SDS; the scale of the growth underlines the need for training and retraining.

Globally, many companies have already made the transition

- RWE Renewables-started as a coal company
- E.On (originally a state-owned utility)
- Scatec (owned by Equinor, state-owned oil utility)
- Enel (originally a state-owned utility)
- Orsted (Originally an offshore oil and gas company)
- Iberdola (Complicated history, but primarily a gas company/utility)

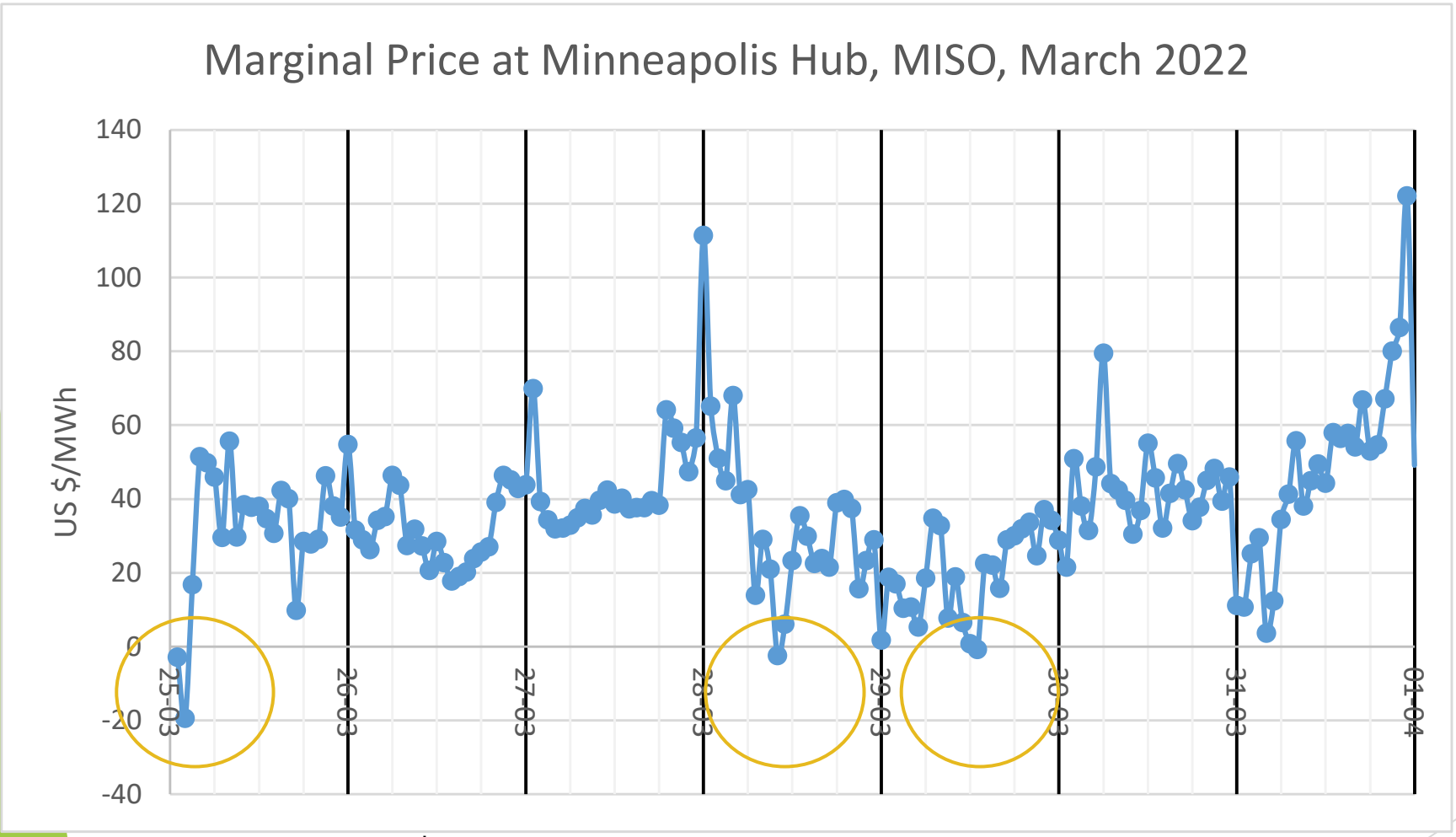
Key Policy recommendations

- Implement Ancillary services market
- Implement Time of Day Pricing
- Cost-reflective tariffs (including direct benefit transfer as required)
- Cost-reflective banking charges, earmarked for grid integration of RE
- Training: India needs lakhs of RE engineers, factory workers, installers, maintenance workers, etc.
- Reduce battery taxes to the same (or lower) than coal
- Investing in R&D for make-in-India for the world (eg. floating solar, solar pumps, next-gen batteries, alternate energy storage)
  - What else? AgriPV? Biomass? Sodium batteries? Thorium Nuclear reactors?
- Sunsetting of transmission waiver, but expedited/deemed consent for interconnection requests
  - Solar Resource may not be as strong, but a solar plant at Dadri or Trombay is more valuable than in the Rajasthan desert

Fundamentally, we need a mandate to minimize cost for consumers at both planning and operational level

- Currently, coal plants are effectively subsidised with high VC to run at minimum load even at times of surplus (eg. The middle of the day, or in the middle of the night or in monsoon season). This high-cost coal power is passed through to consumers
- In contrast, because DISCOMs have to integrate RE (and are not compensated for banking/balancing), they have a strong disincentive to procure/allow interconnection of RE, even if it would save cost for end consumers!
- Solution: Integrated Least Cost Resource Planning (incl. retiring of existing assets, where appropriate)
  - Strengthened SERCs with a mandate to enforce lowest cost/highest reliability for consumers
  - Plan for both energy and resource capacity needs, optimized to reduce both.
  - At operational level, fully implement MBED/SCED (next slide)
  - Eliminate double standard where coal plants can be contracted on a bilateral basis whereas RE must be competitively tendered. All SERCs should seek to do least-cost resource planning from all technologies

Fully implementing MBED/SCED solves other problems that are currently being solved through regulation



Weekly average price of $36/MWh (~ Rs. 2.8/kWh), but low-demand hours, price dips below 0

No need to regulate minimum generation or ramp rates! Plants decide for themselves if it is more economic to

a) Accept occasional low (or negative prices) or

b) Accept high shut-down/start-up (or ramp-down/ramp-up) costs or

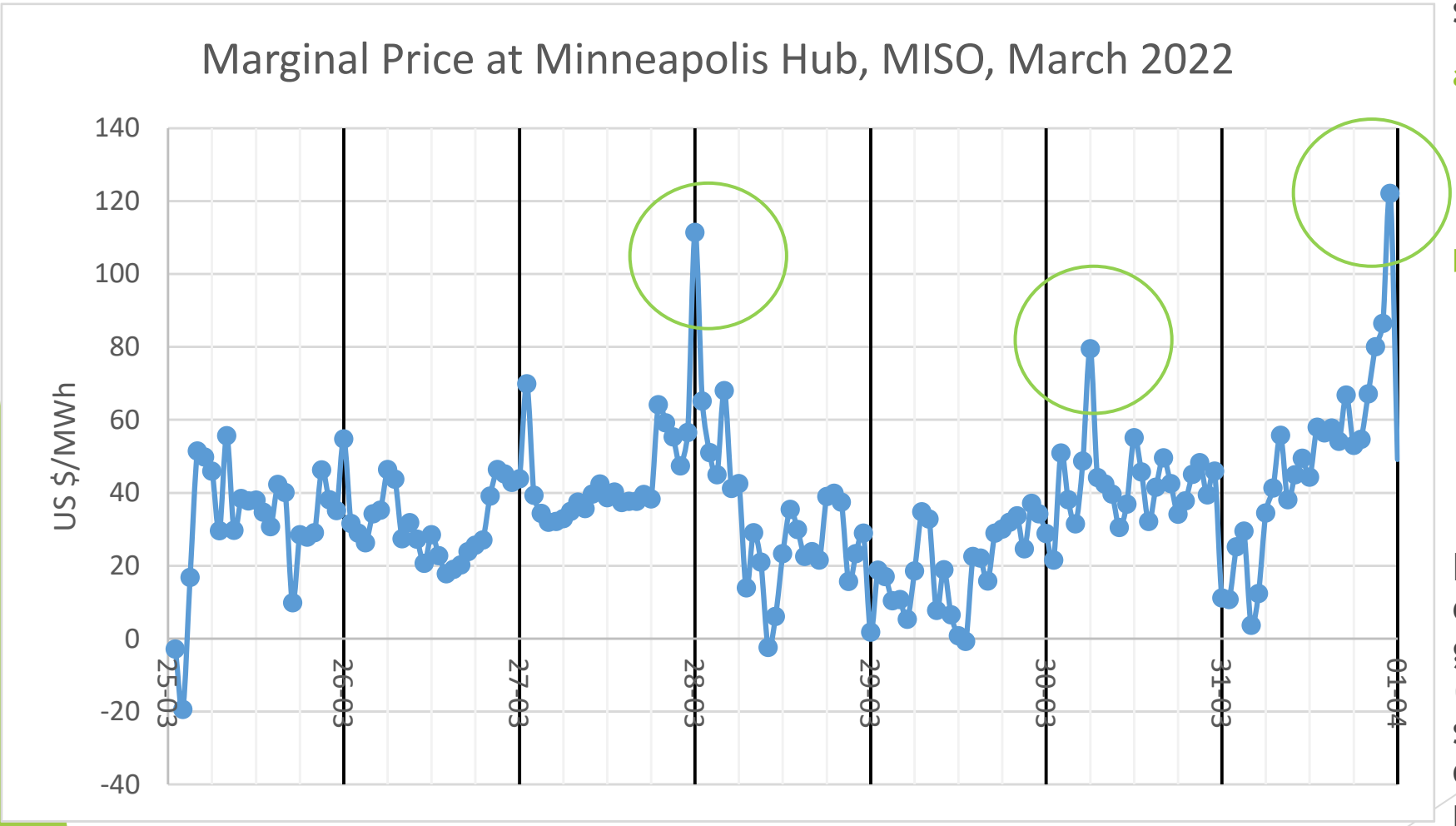
c) Retrofit to be more flexible

Low Flexibility, low VC (baseload) plants will still make money on average

High flexibility, High VC (peaking) plants will make money on peaks and turn off/down on troughs

Low flexibility, high VC plants are not providing value (even before RE)-they are effectively being subsidized and should be driven out based on economics alone!

Fully implementing MBED/SCED solves other problems that are currently being solved through regulation



11/168 block price rose above $60/MWh (Rs. 4.5/kWh)

No need for special incentives for gas/hydro/biodiesel/battery storage/pumped hydro

a) Plants with low FC but high VC (eg. OCGT, biodiesel, Demand Response) will bid when prices are high

b) Energy storage can make money off high-low arbitrage on top of ancillary services revenue/capacity auctions (and will provide a natural price cap- no need for an artificial cap imposed by government!)

Bilateral contracts can still be used for capacity planning, but 100% of generation should go through market (with contracts settled financially on say a monthly basis eg. CfD). If 100% of generation goes through market, proper price signals will incentive the required generation

Opportunity

- Indian companies can become global leaders in RE, building on existing strengths
- RE build must ramp up aggressively, to at least 35 GW/year (to meet demand growth), but for economic reasons (high cost coal retirements) alone more like 65-75 GW/year
  - On top of that, may wish to achieve environmental/employment objectives through further thermal retirements, Green Hydrogen, transport electrification, etc.
- Redirecting capital from thermal to RE can save Indian consumers (and financially stressed DISCOMs) 50,000-80,000 Cr/year (on top of BAU 450 GW target)
  - Investing in peaking resources will also improve energy access and reduce diesel consumption
- State and Central governments are at an inflection point. Continue to burden Indian consumers by building expensive new coal or massively scale up targets and deployment of RE + storage, grow the business and become a world leader
- “Energy access should not be the privilege of the rich”. Massively scaling up RE can finally provide affordable, reliable power to the masses, not just to the rich who are served by the existing system