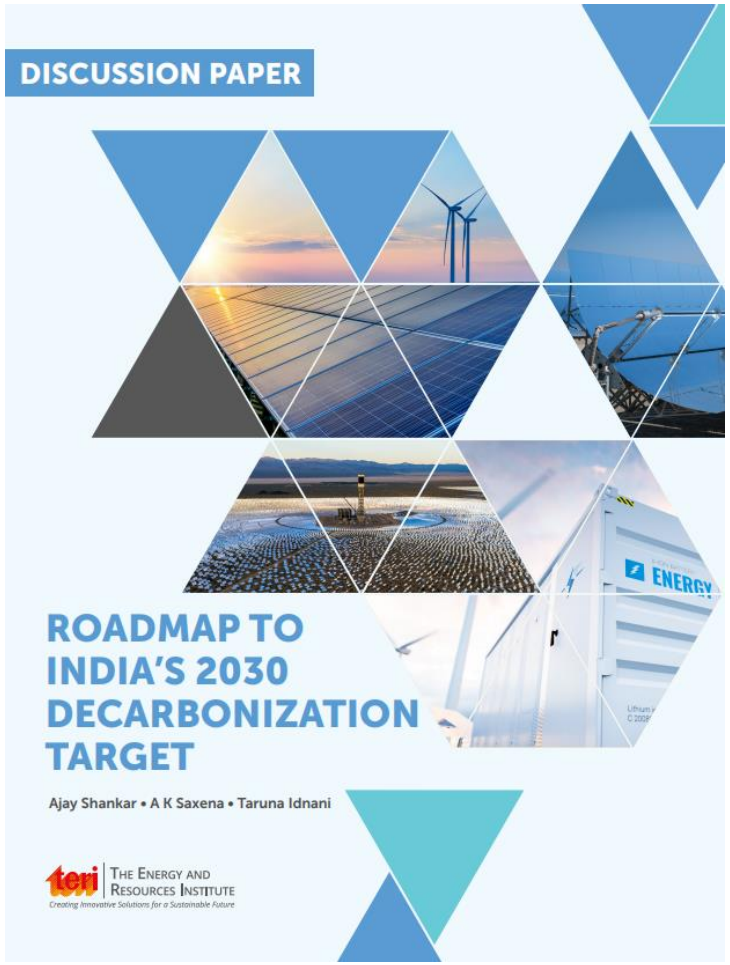
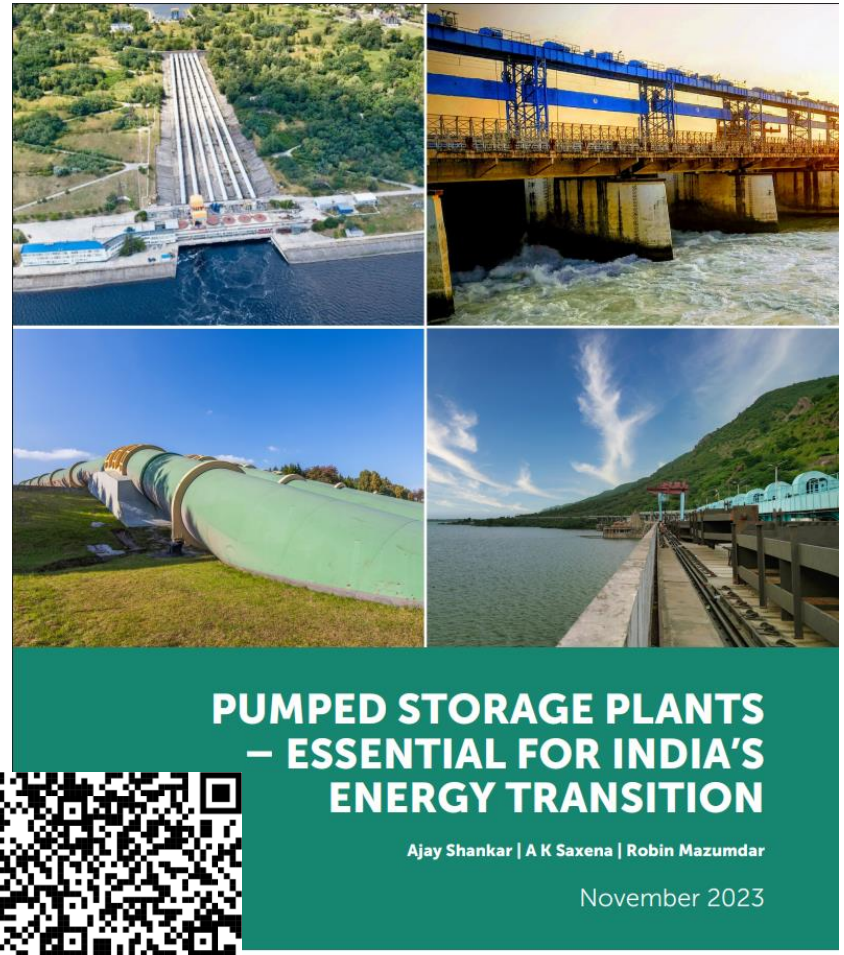
Solar Plus Storage: Cost Analysis of Round-the-Clock Supply for a Typical Day

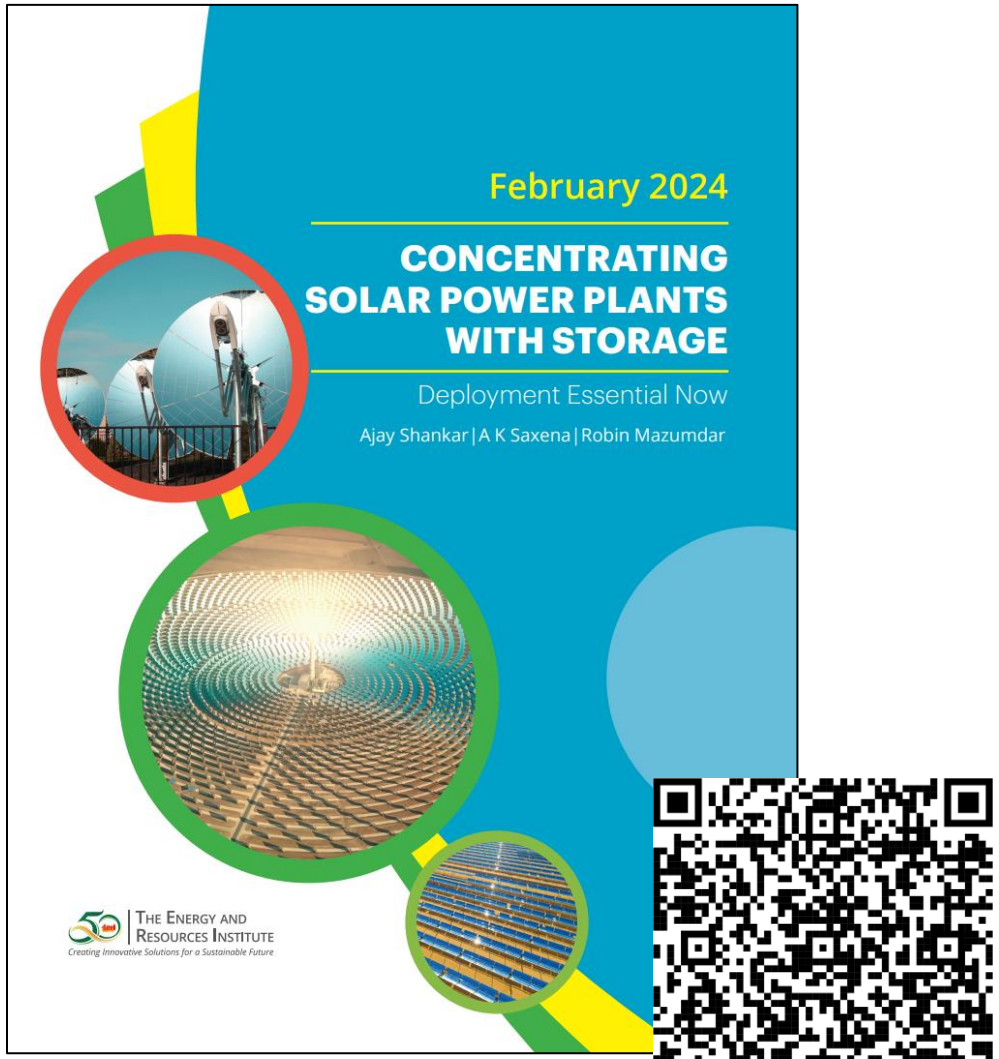
TERI's Report on Roadmap to India's 2030 Decarbonisation Target

- The report (July 2022) outlined a roadmap for achieving India's COP26 commitments identified energy storage as a key enabler to realise the 2030 targets.

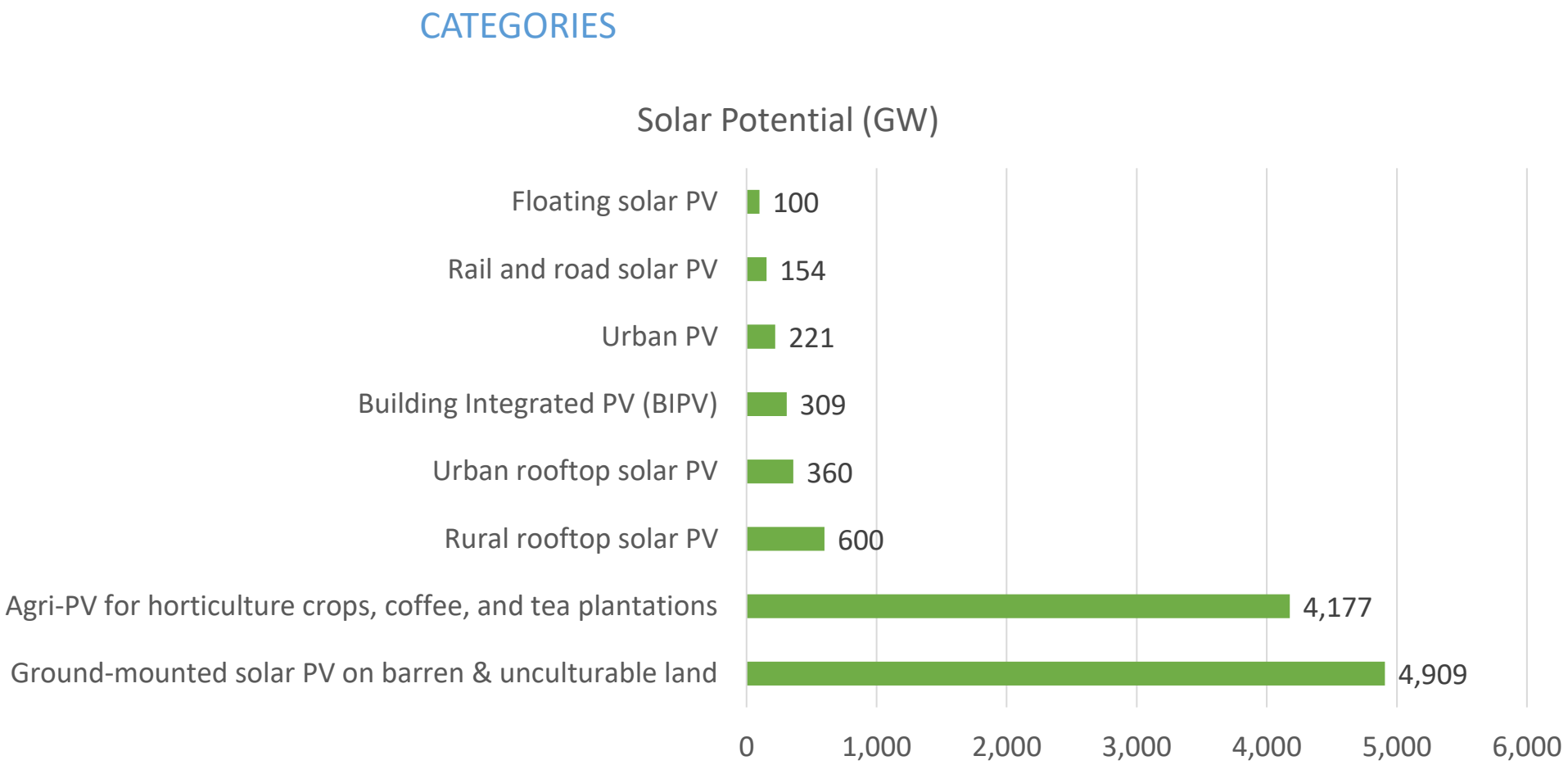


TERI's Subsequent Work on Storage Solutions

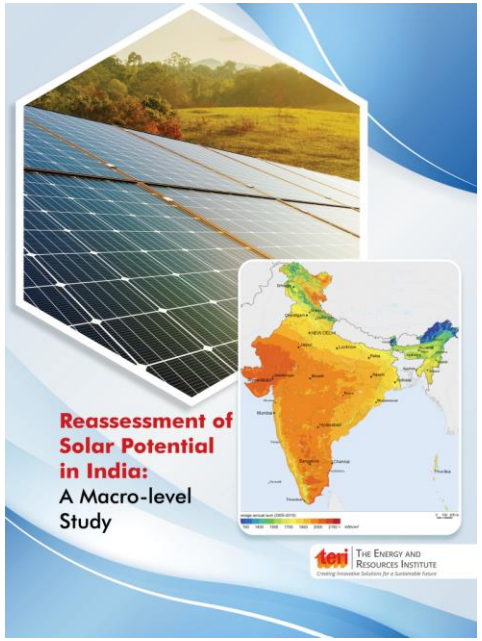




TERI's Report on Re-Assessment of Solar Potential: A Macro-Level Study



Average Total Potential: 10,830 GW



Cost Analysis of Solar + Storage for Delhi (BRPL Case Study)- Methodology

OBJECTIVE

To **compare the per-unit cost of electricity** required to fully meet BRPL's daily demand using:

- **Solar + BESS**
- **Solar + PSP**
- **New Thermal Power Plant** (as benchmark)

APPROACH/METHODOLOGY

- Selected **four representative days (2022–23)** from BRPL's electricity demand data.
- Created **theoretical solar generation curves** using PVWatts for each season's day.
- Matched hourly **solar output against demand** to determine:
  - Solar energy directly used during daylight hours.
  - Energy required from **storage** to meet non-solar-hour demand.
- **Iteratively sized solar and storage capacities** to ensure full daily demand coverage.

Cost Analysis of Solar + Storage for Delhi (BRPL Case Study)- Methodology

SYSTEM DESIGN ASSUMPTIONS

- **Solar generation cost:** ₹2.5/kWh (assumed based on prevailing tariff benchmarks).

- **Storage costs[1]:**
  - PSP: ₹3.81/kWh (delivered, excluding pumping)
  - BESS: ₹2.8/kWh (2-hour systems)

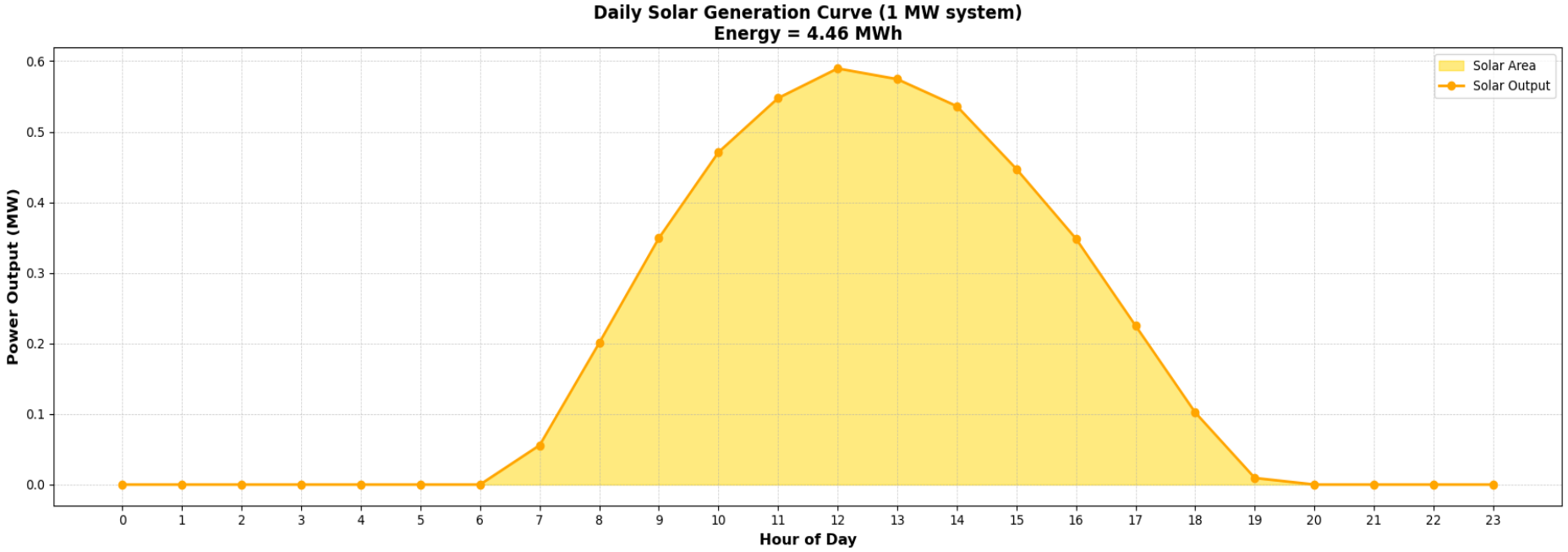
- **Round-trip efficiencies[2]:**
  - PSP: **80%**
  - BESS: **85%**

- In this theoretical exercise, only the **generation and storage costs** are considered.
- Transmission charges and losses, open access charges, wheeling charges, cross-subsidy charges and financing costs are excluded.

Source: 1. TERI's PSP Report and IESA 2. Indian Technology Catalogue (CEA, DEA, GSP)

Generation Analysis of Solar + Storage for Delhi (BRPL Case Study) (1/5)

Summer Peak Day: 28th June 2022 **CASE 1: BESS**



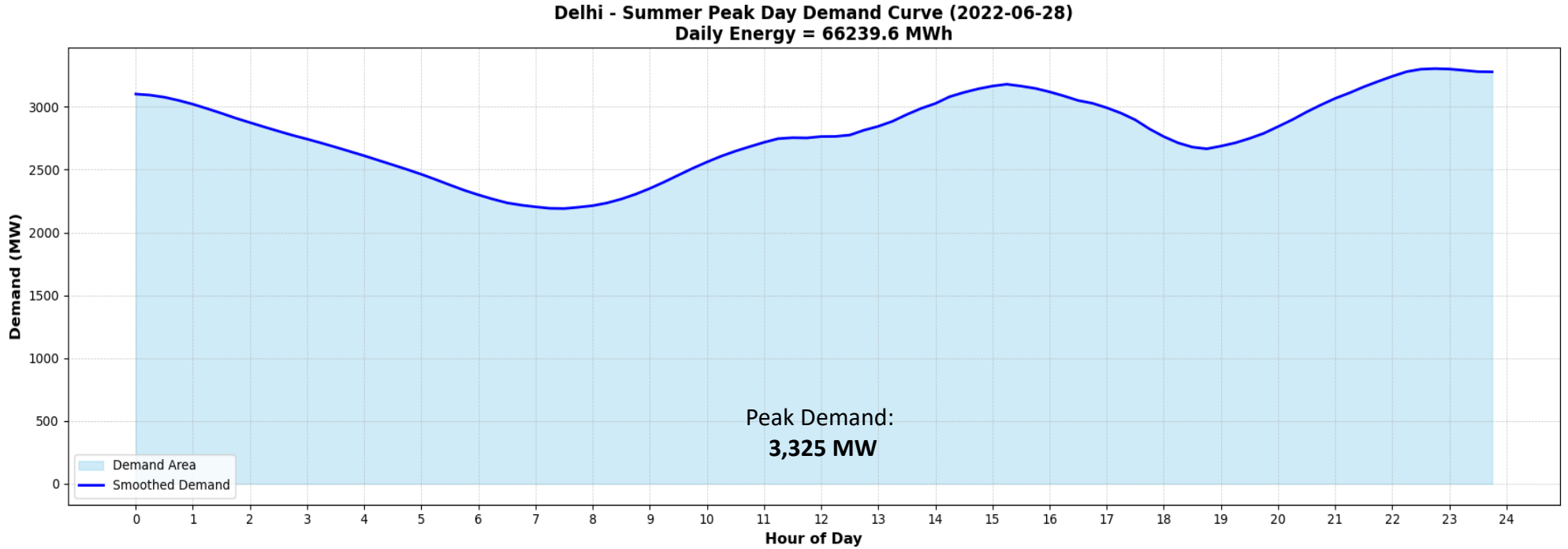
Solar energy generation from 1 MW (MWh/day)	4.46

For optimal capacity, calculated solar multiplier to get solar generation to meet demand during solar hours directly and non-solar hours through storage.

Source: PVWatts Calculator

Generation Analysis of Solar + Storage for Delhi (BRPL Case Study) (2/5)

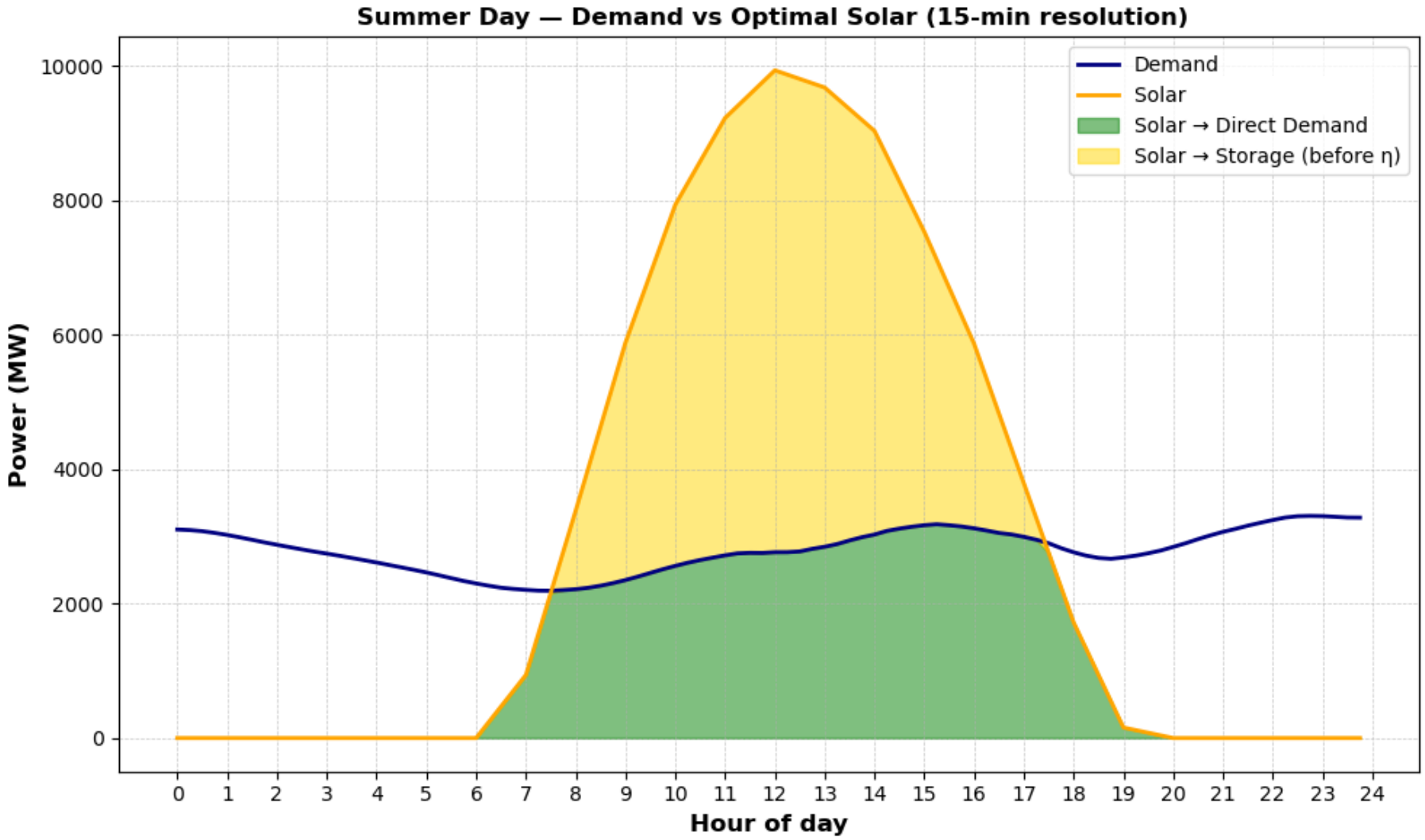
Summer Peak Day: 28th June 2022 **CASE 1: BESS**



Parameter (MWh)	Value
Total daily energy demand	66,240
Energy demand during solar hours	36,675
Energy demand during non-solar hours	29,565

Generation Analysis of Solar + Storage for Delhi (BRPL Case Study) (3/5)

Summer Peak Day: 28th June 2022 **CASE 1: BESS**



Generation Analysis of Solar + Storage for Delhi (BRPL Case Study) (4/5)

Summer Peak Day: 28th June 2022 **CASE 1: BESS**

Parameter	Value
Approximate total solar capacity needed (MW)	16,270
Total solar energy generation (MWh)	72,503
Solar generation directly used for demand (MWh)	30,967
Excess solar generation (MWh)	41,536
Energy available for storage after losses (MWh)	35,305
Energy drawn from storage for solar-hour deficit (MWh)	5,740
Non-solar hour demand met through storage (MWh)	29,565
% of solar generation used directly for demand	42.7
% of solar generation sent to storage (before losses)	57.3

Generation Analysis of Solar + Storage for Delhi (BRPL Case Study) (5/5)

Summer Peak Day: 28th June 2022 **CASE 2: PSP**

Parameter	Value
Approximate total solar capacity needed (MW)	16,845
Total solar energy generation (MWh)	75,066
Solar generation directly used for demand (MWh)	31,104
Excess solar generation (MWh)	43,962
Energy available for storage after losses (MWh)	35,170
Energy drawn from storage for solar-hour deficit (MWh)	5,605
Non-solar hour demand met through storage (MWh)	29,565
% of solar generation used directly for demand	41.4
% of solar generation sent to storage (before losses)	58.6

Cost Analysis of Solar + Storage for Delhi (BRPL Case Study) (1/2)

$$Cost_{System} = \frac{Total\ Generation_{Solar} \times Cost_{Solar} + Generation\ Delivered_{ESS} \times Cost_{ESS}}{Total\ Demand}$$

- PV cost applies to all PV generation and storage tariff excludes charging energy.
- A 2-hour BESS system has been assumed as competitively discovered prices for the same are available to serve as a good reference. Many such 2-hour BESS can be installed to enable the supply of electricity to fully meet the demand curve of the day.

Source: Source of PSP costing- TERI Report, 2024

Cost Analysis of Solar + Storage for Delhi (BRPL Case Study) (2/2)

SUMMER DAY 28 June 2022	BESS	PSP
Total generation by solar (MWh)	72,503	75,066
Total generation delivered by storage (MWh)	35,305	35,170
Solar PV tariff (Rs/kWh)	2.5	2.5
Standalone Storage tariff (Rs/kWh, excluding charging costs)[1]	2.8	3.81
Total energy demand (MWh)	66,240	66,240
Weighted average cost per unit system (Rs/unit)	4.23	4.86

Source: 1. Source of BESS Costing and PSP costing- IESA, TERI Report, 2024

Cost Analysis of Solar + Storage for Delhi (BRPL Case Study)- Summary

COST ANALYSIS	SUMMER DAY 28 June 2022		WINTER DAY 10 January 2023		AUTUMN DAY 9 September 2022		SPRING DAY 30 April 2022	
	BESS	PSP	BESS	PSP	BESS	PSP	BESS	PSP
Total generation by solar (MWh)	72,503	75,066	39,870	41,039	63,906	66,189	56,914	58,962
Total generation delivered by storage (MWh)	35,305	35,170	16,181	16,096	31,445	31,325	28,189	28,085
Solar PV tariff (Rs/kWh)	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Standalone Storage tariff (excluding charging costs)	2.80	3.81	2.80	3.81	2.80	3.81	2.80	3.81
Total energy demand (MWh)	66,240	66,240	36,996	36,996	58,328	58,328	51,914	51,914
Weighted average cost per unit system (Rs/unit)	**4.23**	**4.86**	**3.92**	**4.43**	**4.25**	**4.88**	**4.26**	**4.90**

Cost Analysis of Solar + Storage for Delhi (BRPL Case Study)- Conclusion

- **BESS-based systems** are consistently **cheaper than PSP-based systems**.
- Both solar + storage configurations are **already competitive with new thermal generation**.
- These results **exclude additional costs** such as **transmission charges and losses, open access charges, land cost, and financing cost**, focusing only on generation and storage costs.
- Considering **thermal power tariffs of ₹5.4–₹5.8/kWh**, **solar + storage is emerging as a viable and cleaner 24×7 supply option.**

System	Range of Cost (₹/kWh)
Solar + BESS	3.92 – 4.26 ₹/kWh
Solar + PSP	4.42 – 4.9 ₹/kWh
New Thermal Power	5.5–5.8 ₹/kWh