Power Pairing: Co-Locating PV & Energy Storage Solutions

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INTERNATIONAL
SOLAR
ALLIANCE

ISA is on a Mission to Solarize the World

ISA is on a Mission to Solarize the World by 2030

Who we are

- **Inter-governmental treaty-based international organization** with a global mandate to **catalyse global solar growth**
- Launched by **Hon'ble Prime Minister of India**, and former **French President**
- Till date, **123 countries** have signed the ISA Framework Agreement
- ISA is helping to attain **SDG 7** (Universal Energy Access) and **SDG 13** (Combating Climate Change)

ISA Mission

- Enabling Energy Transition of **1,000 GW** of Solar Capacity
- Reducing Carbon Emissions by **1,000 Million Tonnes**
- Ensuring Energy Access for **1,000 Million People** using Clean Energy Solutions
- Mobilizing **USD 1,000 Billion** in Solar Investments

Key Issues

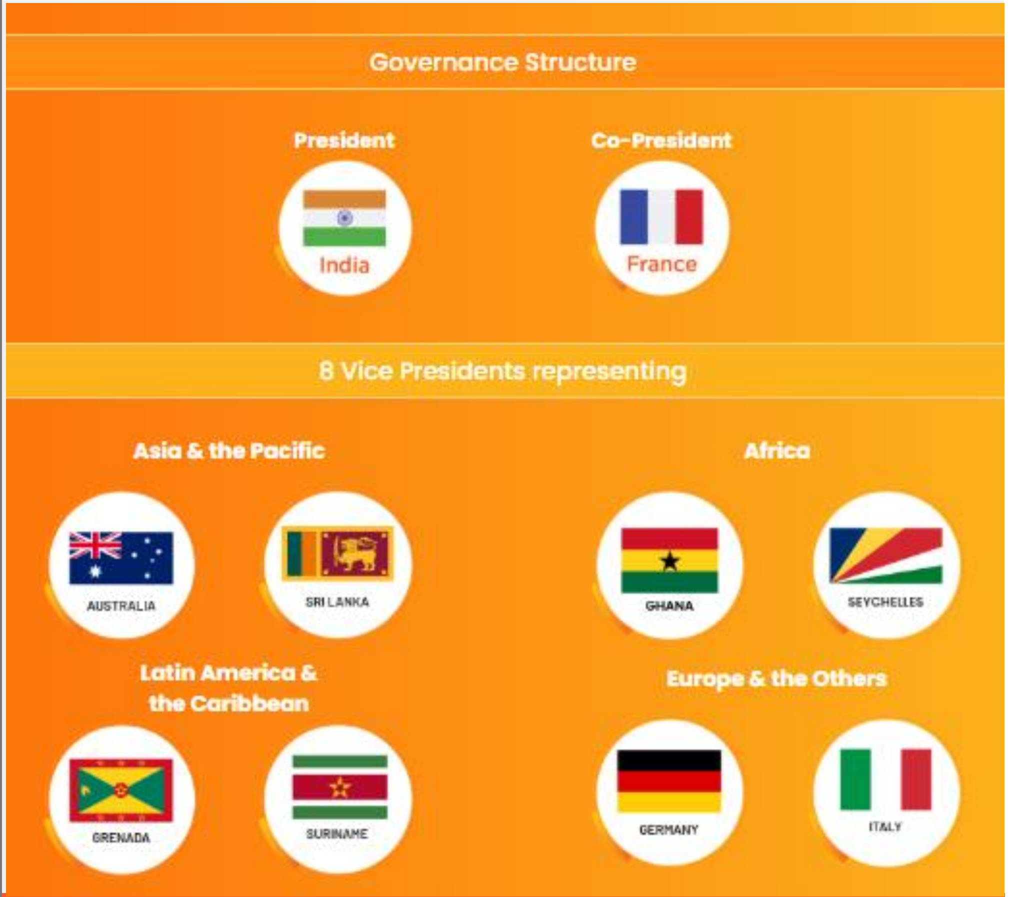
- Energy Access
- Energy Security
- Energy Transition

Priority Areas

- Analytics & Advocacy
- Capacity Building
- Programmatic Support

ISA Evolution and Impact

INTERNATIONAL SOLAR ALLIANCE



ISA is working with Member Countries to develop conducive policies to bring in investments in solar

123

Member and Signatory Countries

Analytics and Advocacy

Capacity Building

Programmatic Support

Currently operating out of National Institute of Solar Energy with an outreach office at Scope Complex

9.5 GW

Aggregated capacity from 44 Member Countries

27

Demonstration Projects facilitated across SIDS and LDCs

50%

Global price reduction of solar pumps through demand aggregation

4,500

Trained Master Trainers, Professionals, Bankers, and Technicians Across 55 Countries

ISA Demonstration Solar Projects

47 Countries – Eligible LDCs/ SIDS member
27 Countries – Total Proposal received
27 Countries – DPR Finalized
27 Countries – Grant Agreements Signed
22 Countries – Project Completed

Solarisation of Health Centers (9)

Country Implementation (8)
- Benin
- Burkina Faso
- Guyana
- Mali
- Niger
- Mauritius
- Fiji
- Comoros

ISA Implementation (1)
- * Uganda

Solar Cold Storage (4)

Country Implementation (0)

ISA Implementation (4)
- Djibouti
- Senegal
- Seychelles
- Bhutan

Transferred from Sudan

Solar Water pumping (10)

Country Implementation (5)
- Gambia
- Jamaica
- Togo
- Tonga
- Nauru

ISA Implementation (5)
- Burundi
- Cuba
- Ethiopia
- Mozambique
- Suriname

Other Areas (5)

Country Implementation (3)
- 1 Cambodia
- 2 Kiribati
- 3 Samoa

ISA Implementation (2)
- 4 Malawi
- 5 * Uganda

1. School Buildings
2. School Buildings
3. Streetlights
4. Parliament Buildings
5. School Buildings

Completed in 2022

Completed in 2023 & 24

*Two solar programs (Solarization of 01 Healthcare centre & 03 Primary schools) are being implemented in Uganda

ISA Programmes

To attain SDG 7 (universal energy access) and SDG 13 (combating climate change) goals

Current Programmes (9):

Centralized

- **Solar Park/Floating Solar**

Decentralized

- **Scaling Solar Mini-Girds**
- **Scaling Solar Rooftop**
- **Scaling Solar Application of Agricultural Use**
- **Solar Heating and Cooling Systems**

Cross Cutting

- **Affordable Finance at Scale**

Emerging Programmes

- **Solar PV and Battery Waste Management**
- **Solar for Green Hydrogen**
- **Scaling Solar E-Mobility & Storage**

Role of ISA

Support the assessment of readiness levels and facilitate the deployment of Energy Storage systems including Green Hydrogen in ISA member countries-

01	02	03	04	05
Enabling policy and regulatory framework	Identifying technological gaps; 'go-to' resources	Facilitating investment environment for commercially viable storage projects including GH	Identification of viable projects pipeline across storage technologies	Creating global synergies & leveraging partnerships with public and private sector

Partnerships and Outreach

ISA Knowledge Products: Expected Outcomes

Country Insights
(Readiness Assessment, Country Prioritization, Country-level deep-dive studies, and project pipelines)

Feasibility Studies
(Techno-Economic analysis, cost benefit analysis, impact assessment and business models)

Capacity Building
(Toolkits, Guidelines, Training Workshops, Webinars)

International Partnerships and Collaborations

International Forums and Organisations

MDBs and Donor Agencies

Events and Outreach

ISA Panel presentation at the **Energy Storage Partnership ESMAP meeting** in South Africa, 27 November 2023

CoP 27 & CoP28 Sessions on **Storage**
(Co-hosts: ADB, CEM, NREL, IESA),
2 December 2023

ISA Panel presentation on '**Long Duration Energy Storage**' at the **India Smart Utility Week** (ISUW), New Delhi,
15 March 2024

ISA-IESA joint learning sessions under "**Future Energy Learning Centre**" at the **India Energy Storage Week**, IICC, New Delhi,
1-2 July 2024

CoP29 Session on Bridging the Energy Gap: Accelerating Solar Adoption with Storage, Co-hosts: ADB, CEM
11 November 2024

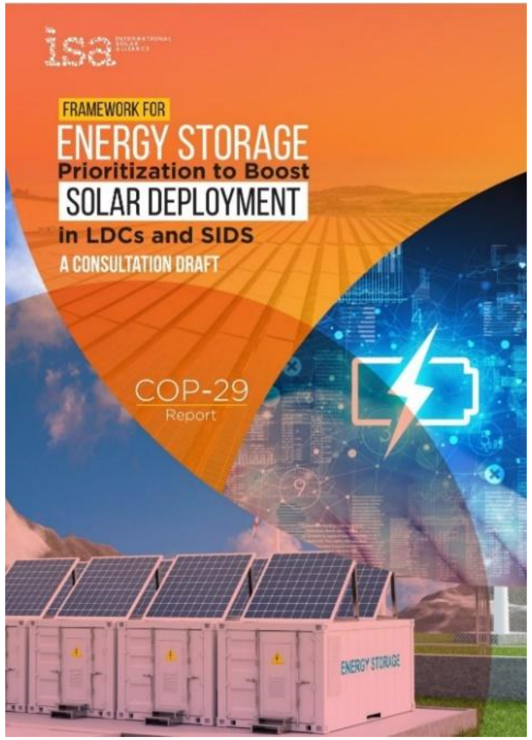
6th Meeting of ISA's **Regional Committee Meeting (LAC)**; Side event on '**Enabling large scale deployment of energy storage systems: ISA Perspective**' (Santo Domingo, Dominican Republic, 10-11 September 2024)

TERI-ISA session on **Framework for Energy Storage Prioritization to Boost Solar Deployment in ISA member countries** at World Sustainable Development Summit (New Delhi, 5 March 2025)

ISA: Ongoing & Planned Work: 2024-2026

Project-1: Energy Storage System (Short & Medium Duration)	Project-2: Energy Storage System (Long Duration)
Phase-1 (2024-25) : Developing Prioritisation Framework for Short and Medium duration storage system for Accelerating Solar Project Deployment in LDCs and SIDS	**Phase-1 (2024-25):** Scaling Solar integrated LDES: Prioritisation and Developing Implementation Roadmap; Identification of project pipelines in Developing Nations
Phase-2 (2025): Country-level Deep Dive Report on Feasibility Studies and Impact Assessment; Pilot Pipeline Identification	**Phase-2 (2025):** Country-level Deep Dive Report on Feasibility Studies and Impact Assessment; Pilot Pipeline Identification
Phase-3 (2026-): Pilots Implementation	**Phase-3 (2026-):** Pilots Implementation

Updates



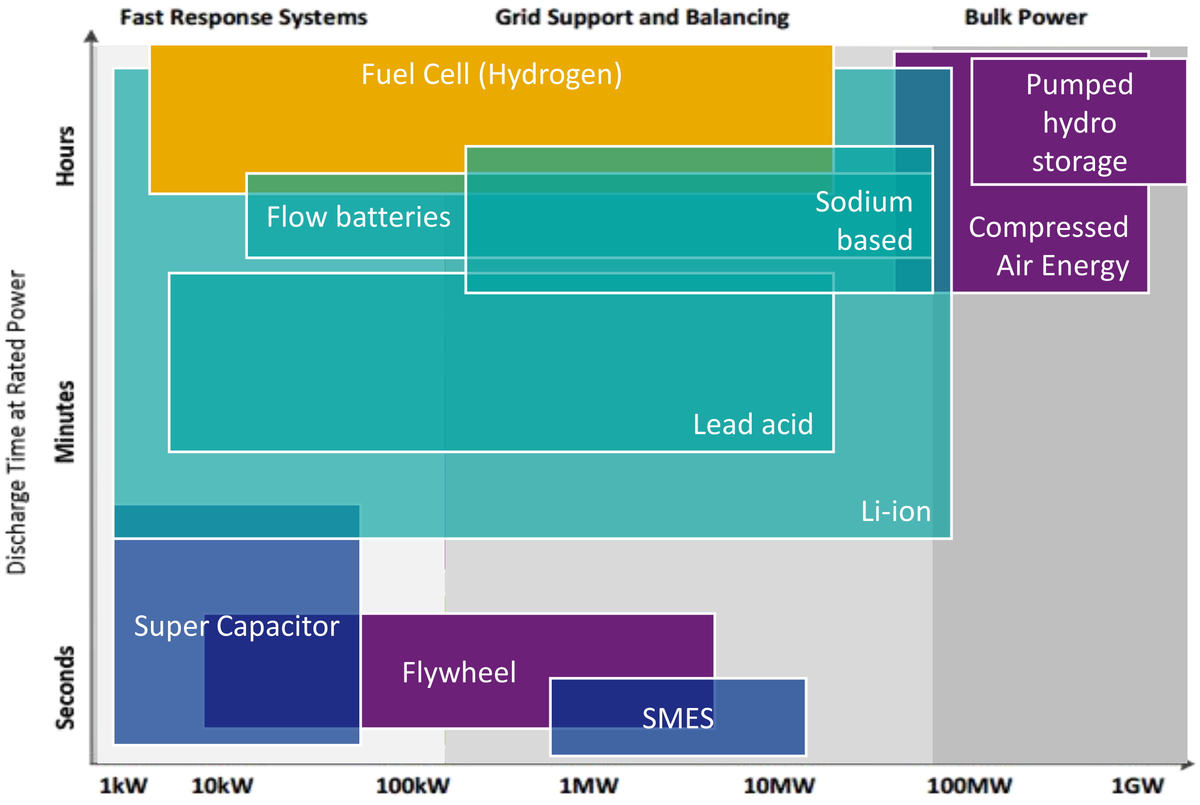
Launch of "[Framework for Energy Storage Prioritization to boost Solar Deployment in LDCs and SIDS: a consultation draft]" at COP 29

LDCs: Least Developed Countries; SIDS: Small Island Developing States

Why New Technologies

	Long Term	Medium Term	Short Term
Mechanical	▪ PHES, ▪ Compressed Air ▪ Liquid Air	▪ PHES, ▪ Gravity Storage ▪ Compressed Air	Flywheel
Electro-chemical	▪ Aqueous Electrolyte Flow ▪ Metal Anode ▪ Hybrid Flow	▪ Lithium Ion, ▪ Sodium Ion ▪ Metal Air ▪ Solid State ▪ Redox Flow ▪ Hybrid Flow ▪ Lead Acid ▪ Sodium Sulphur	
Chemical	Hydrogen		
Electrical			• Super Capacitors • Super Conducting Magnetic Energy Storage
Thermal	▪ Molten Salt ▪ Concrete Storage ▪ Rock Storage ▪ Latent Heat Storage		

- Each storage technology offers solutions for applications from kW to MW to GW scale



Source: Australian Renewable Energy Agency

Comparative analysis of Storage technology basis technical and commercial parameters

Objective

- To identify relevant technical and commercial characteristics of storage technologies
- To map the characteristic of each technology
- To compare technologies based on their performance on technical/ commercial parameters

Technology comparison on technical parameters

Technology	Power density	Discharge duration	RtE	Response time	Deployment Ease
Lead acid batteries	Medium	Medium	High	High	High
Lithium-ion batteries	High	Medium	High	High	High
Sodium-ion batteries	Low	Medium	High	High	High
XX	XX	XX	XX	XX	XX
XX	XX	XX	XX	XX	XX

Non-Exhaustive

Technology comparison on commercial parameters

Technology	Global vendor ecosystem	Raw material constraints	TRL	Scale of operations	Total score
Lead acid batteries	3	3	3	3	**18**
Lithium-ion batteries	3	1	3	3	**17**
Sodium-ion batteries	2	3	2	2	**14**
XX	XX	XX	XX	XX	XX
XX	XX	XX	XX	XX	XX

Non-Exhaustive

Analysis of typical storage characteristics required for different use cases

Objective

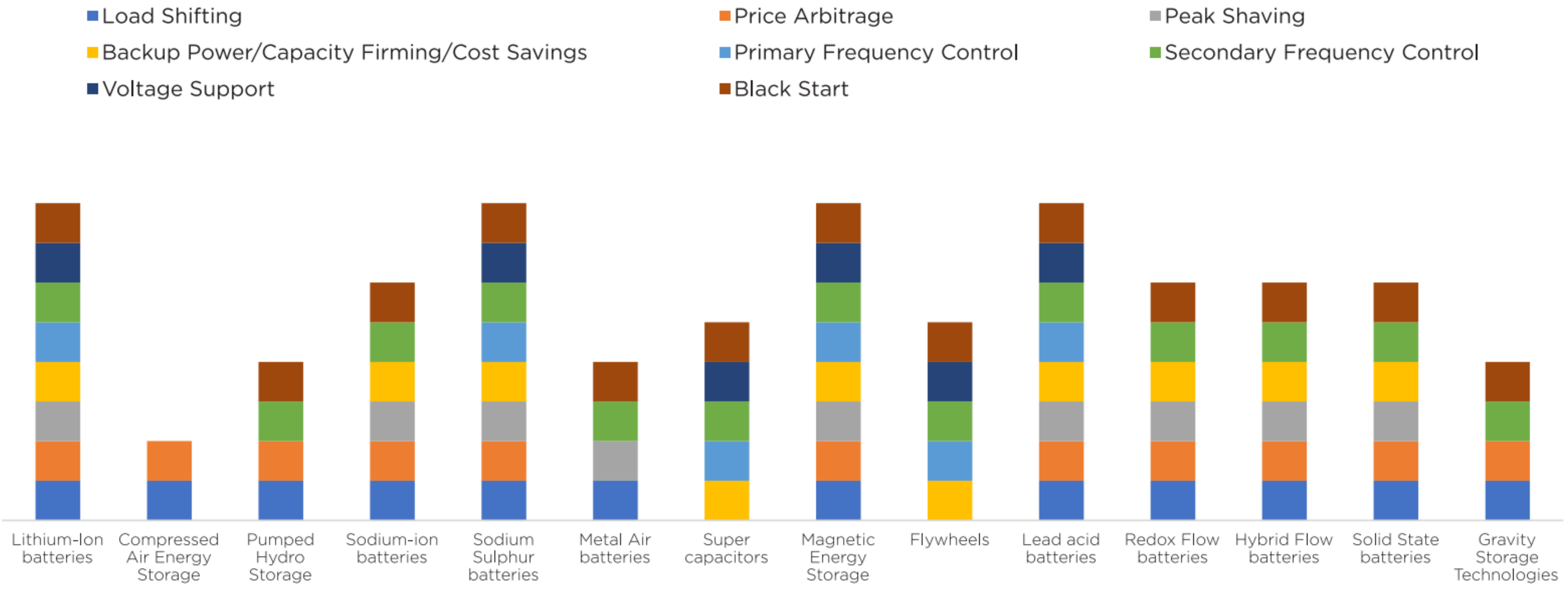
- List the application areas for energy storage
- Identify the key storage characteristics required for each use case

Application Areas	Use Cases	Description	Defining Category 1 Parameters	
Utility Energy Management	Load Shifting	To temporarily shift excess energy and match the energy with the load to reduce or impede energy deficits and curtail usable energy	Discharge Duration	
	Price Arbitrage	To take the benefit of profit generated by buying and selling the same asset in different markets at different timeframes without risk	Round Trip Efficiency	Discharge Duration
C&I Energy Management	Peak Shaving	To reduce the load peaks, especially for industrial consumers during the day by charging during off-peak hours and discharging during peak hours	Deployment Ease	Discharge Duration
	Backup Power/ Capacity Firming/Cost Savings	To minimize the consumption of expensive and polluting fossil fuels and to act as a backup power source during times of power outages or equipment failures	Round Trip Efficiency	Deployment Ease
Ancillary Services	Primary Frequency Control	To act to arrest the frequency variation and restabilize it	Response Time	Power Density
	Secondary Frequency Control	To return the system frequency to a non-critical value, typically over minutes	Response Time (milliseconds to seconds)	
	Voltage Support	To inject power in grid to maintain voltages within acceptable ranges at every stage between each end of power line	Response Time	Power Density
	Black Start	To restore the energy in electrical device, station, or power plant following a blackout (power outage) without external electrical supply	Response Time (milliseconds to seconds)	

Mapping: Technologies for different use cases

Objective

To select storage technologies that satisfy the technical characteristics required for each use case



Source: ISA COP29 report on *[Framework for Energy Storage Prioritization to boost Solar Deployment in LDCs and SIDS: a consultation draft]()*

Co-location

*It is the practice of **placing two or more related infrastructure components in close physical proximity** to optimize efficiency, reduce costs, and enhance performance.*

Co-location in Solar Sector – Generation meets Storage

*In **solar energy**, co-location means **installing solar PV systems alongside energy storage systems (ESS)** at the same location. This allows excess solar energy to be stored and used during periods of high demand or low sunlight, enhancing grid reliability.*

"Power Pairing"

Solar and energy storage were described by Elon Musk as going together "like peanut butter and jelly".

"Power Pairing"

Upsides of ‘Power Pairing’ - PV and Energy Storage

Grid Stability and Demand Management	• Reduces grid fluctuations caused by intermittent solar generation. • Enhances **power quality and reliability** by providing stored energy during peak demand hours. • **Frequency and voltage regulation** are improved, reducing the risk of blackout
Transmission Cost Optimization	• **Better utilization of transmission infrastructure**—electricity generated during the day can be stored and dispatched during peak evening hours, reducing grid congestion. • Reduces the requirement for new transmission lines, optimizing grid investments
Energy Arbitrage and Market Benefits	• **Energy shifting**: Store excess solar power when generation is high and demand is low, then sell it when prices are higher. • Enables **participation in ancillary services** (frequency regulation, spinning reserves) for additional revenue streams
Accelerating Renewable Energy Integration	• Facilitates **hybrid RE projects** (e.g., solar-wind-storage) for more stable power supply

Downsides of ‘Power Pairing’ - PV and Energy Storage

High Initial investment

- Battery storage remains expensive, although costs are decreasing.
- Requires substantial capital investment for both PV and ESS infrastructure

Land and infrastructure challenges

- Land constraints make it difficult to develop large-scale co-located projects.

Battery Degradation and Replacement Costs

- Lithium-ion batteries (currently dominant in storage sector) degrade over time, requiring periodic replacement

Policy and Regulatory Uncertainty

- Despite government mandates, lack of clear incentives and financing mechanisms slows adoption.

The India Story with ‘Power Pairing’


Ministry of New and Renewable Energy

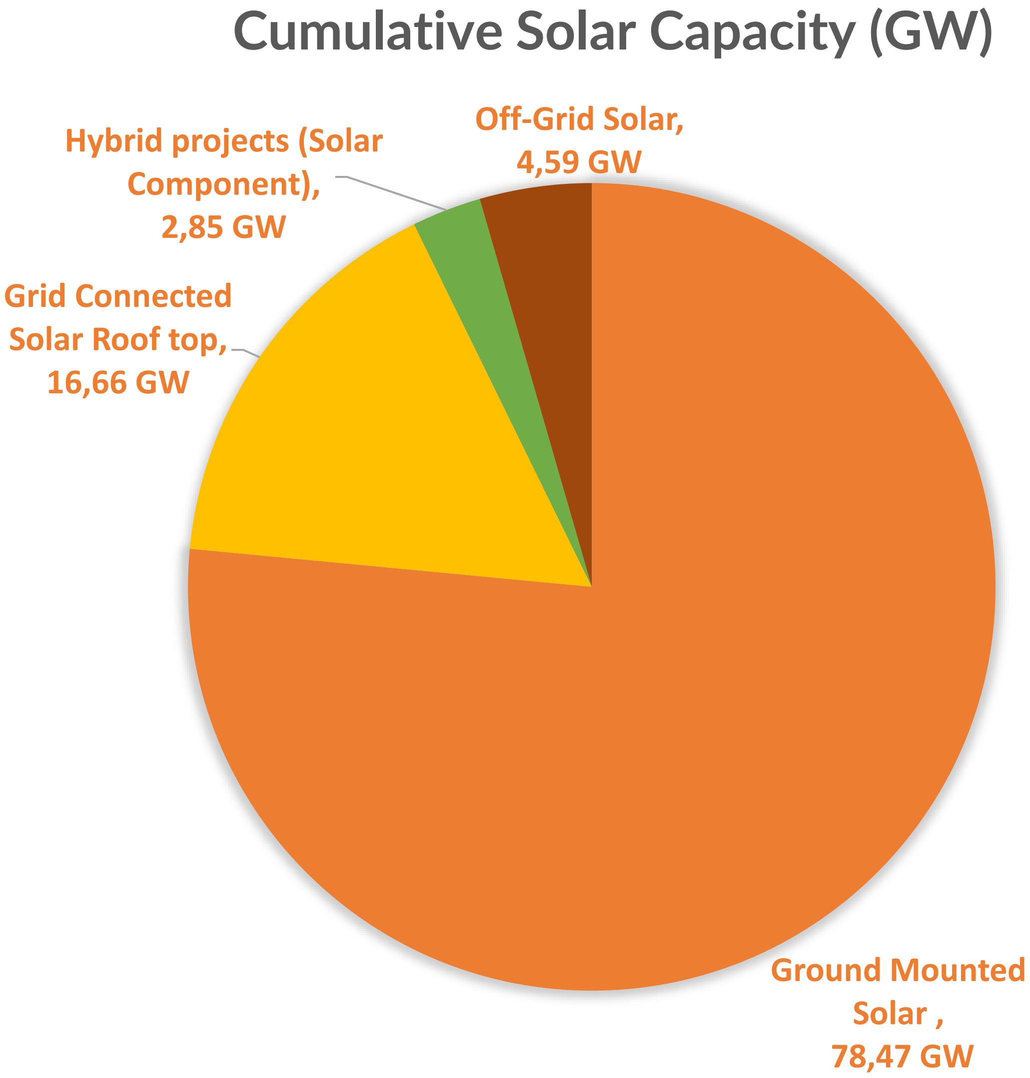
Azadi Ka Amrit Mahotsav

India Achieves Historic Milestone of 100 GW Solar Power Capacity

With 100 GW solar power achieved, India is moving towards energy independence and a greener future: Union Minister Pralhad Joshi

*India’s solar power sector has witnessed an extraordinary **3450 % increase** in capacity over the past decade, rising from **2.82 GW in 2014 to 100 GW in 2025**.*

*India is on a fast track to achieving **500 GW of non-fossil fuel capacity by 2030**. However, **<u>the intermittency of solar power presents a major challenge.</u>***



As of 28 Feb, 2025 as reported by Ministry of New and Renewable Energy Ministry, India

The India Story- Projections for ESS

- Current installed energy storage capacity (Dec'2024): **4.86 GW** (PSP: 4.75 GW and ESS: 0.11 GE)

- As per **National Electricity Plan (NEP) 2023 of Central Electricity Authority (CEA), projected** energy storage capacity is
  - **2026-27 : 82.37 GWh** (PSP: 47.65 GWh and BESS: 34.72 GWh)
  - **2031-32 : 411.4 GWh** (PSP: 175.18 GWh and BESS: 236.22 GWh)
  - **2047 : 2380 GWh** (PSP: 540 GWh and BESS: 1840 GWh) in light of net zero targets

A long-term trajectory for **Energy Storage Obligations (ESO**) has also been notified by the **Ministry of Power** to ensure that sufficient storage capacity is available with obligated entities. As per the trajectory, **the ESO shall gradually increase from 1% in FY 2023-24 to 4% by FY 2029-30, with an annual increase of 0.5%.** This <u>obligation shall be treated as fulfilled only when at least 85% of the total energy stored is procured from Renewable Energy sources on an annual basis.</u>

- Advisory by Government of India

Feb’2025

India’s Central Electricity Authority recommends energy storage requirement for solar PV tenders

By Jonathan Touriño Jacobo
February 26, 2025

Ministry Of Power Advisory On Co-Locating Energy Storage Systems With Solar Power Projects To Enhance Grid Stability And Cost Efficiency

By **Mohan Gupta** - 19th February 2025

India mandates co-locating energy storage with solar projects

India’s Ministry of Power has mandated all renewable energy implementing agencies and state utilities must incorporate a minimum of two-hour co-located energy storage systems (ESS), equivalent to 10% of the installed solar project capacity, in future solar tenders.

FEBRUARY 20, 2025 UMA GUPTA

Renewable energy plus storage auctions to gain traction in India

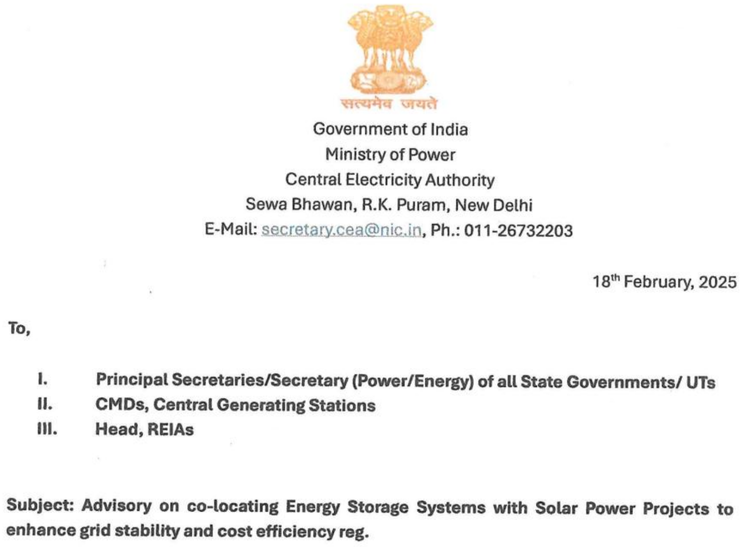
India Ratings says it expects renewable energy and storage tenders to gain further traction in India in the coming years, given the storage requirement of around 74 GW/411 GWh under National Electricity Plan (2023-32).

JANUARY 22, 2025 UMA GUPTA

India Mandates Energy Storage for Solar Projects to Boost Grid Stability

Nirmal Menon, February 20, 2025

The India Story- Government's mandate


सत्यमेव जयते
Government of India
Ministry of Power
Central Electricity Authority
Sewa Bhawan, R.K. Puram, New Delhi
E-Mail: secretary.cea@nic.in, Ph.: 011-26732203

18th February, 2025

To,

I. Principal Secretaries/Secretary (Power/Energy) of all State Governments/ UTs
II. CMDs, Central Generating Stations
III. Head, REIAs

Subject: Advisory on co-locating Energy Storage Systems with Solar Power Projects to enhance grid stability and cost efficiency reg.

- The government has mandated **co-location of PV with storage**, requiring a **minimum of two hours of storage** for new projects (i.e. 10% of installed capacity)
- Distribution licenses may mandate **2-hour storage with rooftop solar plants** as well.
- Storage systems can be used in **Single-cycle operation** (charged using co-located solar power and discharged using evening hours) or **Double-cycle operations** (charged from solar power or grid during low demand hours and discharged during peak hours – especially non solar hours)

GHIC
Green Hydrogen Innovation Center

ISA INTERNATIONAL SOLAR ALLIANCE

ICF

Global Green Hydrogen Startup Challenge

OBJECTIVE
To identify and support startups that offer innovative and scalable solutions in the green hydrogen sector

TARGET SECTORS
Steel and Transport

IMPACT
Serve as a global platform to support innovative green hydrogen startups

SCOPE AND TIMELINES

Shortlisting & outreaching interested donors
for providing the required financial support
November'24 onwards

Global launch & outreach program
for promoting and launching the challenge
December'24 onwards

Global Green hydrogen startup challenge
Shortlisting green hydrogen startups in steel & transport sector
by April'25

Identification and facilitating support to selected startups
at concept phase (Seed Funding and capacity building) or at implementation phase (advisory / networking support)
May'25 onwards

Comprehensive Final Report
by December'25

UNIQUE FEATURES OF GHIC

COUNTRY INSIGHTS
(Country-level announcements, missions and targets)

GREEN HYDROGEN COMMUNITY
(Live interactive platform for the community)

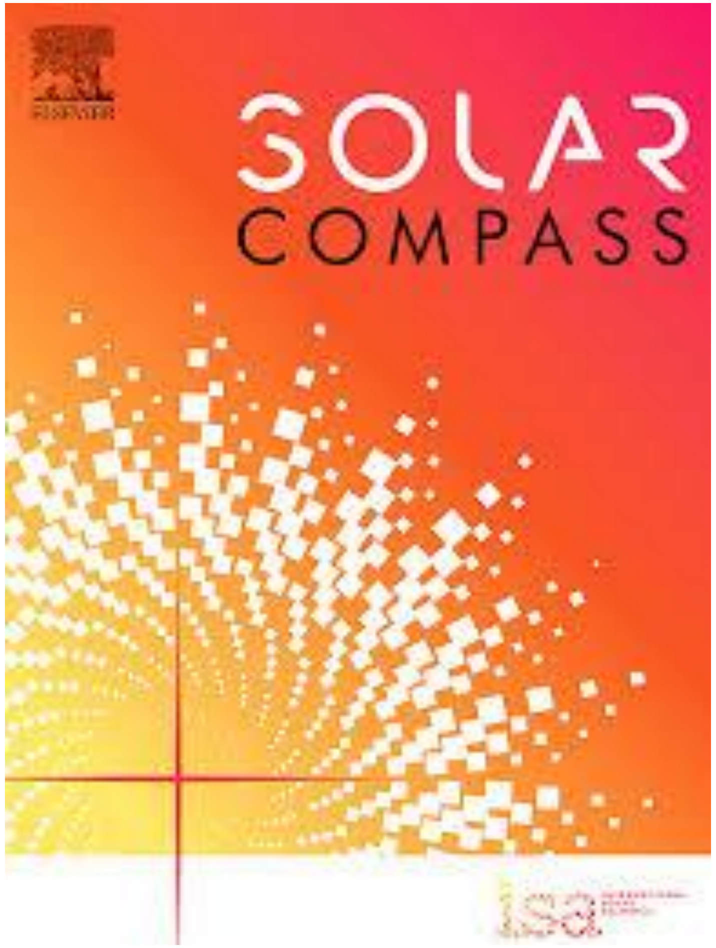
SKILL DEVELOPMENT
(Certified e-learning courses, podcasts, industry expert interview)

LIVE CHATBOT
(AI and ML supported robotic bot for quick support & address queries)

GLOBAL STARTUP PROGRAM
(Platform to support startups and provide opportunities to connect with financiers)

Special Issue – Integrated PV Applications

Guest Editor – Dr. Gurleen Kaur , Co-Guest Editor - Dr. Lawrence Kazmerski



STATUS : **Call for Papers released**

Landing Page Ready - Link

Areas of Interest:

- Agrovoltaics (Agri-PV)
- Floating PV (Floating PV)
- Vehicle Integrated PV (VIPV)
- Building Integrated PV (BIPV)
- Heating and Cooling Applications

IMPORTANT DATES

Submission Deadline: Mar’ 25

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PPIC Team, ISA

KMID Team, ISA

Thank you for your attention