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Session : Long Duration Energy Storage (LDES)

Presented By

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INTRODUCTION- Long duration Energy Storage

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- Effects of variable and intermittent renewable generation:
  Grid operator's task of matching generation and demand in real time becomes more challenging.
- Changing Customer demands:
  Based on the load profile and peak demands.
- Effects of Climate Change:
  Changing climate & weather dependent energy requirements further adds to challenge.
- Decarbonization goal:
  Reduction in fossil fuel-based capacity which as of now majorly contributing to base load.
- These emerging grid conditions are creating an imperative for long-duration energy storage (LDES):
  To ensure Grid Stability, Supply Availability and Reconcile Variable generation resources.

Long-duration storage technology can :

- Knock out coal based and gas peaker plants
- Turn renewables into round-the-clock resources
- In general pave the way for a carbon-free grid.

Quantity	Definition
Energy	Rated discharge for time (MWh)
Time	Duration of discharge (h)
Power	Rated output (MW)

Indian CONTEXT- Why Long Duration Energy Storage?

India's Renewable journey- started in 2009

- ✓ Achieved **172 GW** by 2023
- ✓ Target of RE capacity of **500 GW** by 2030
- ✓ RE will be **60%** of total installed generation capacity

System Requirement - 2030		%
Base Load Station	Coal + Nuclear	30.7
Peak Load Station	Hydro + Gas	9.3
Veriable/Intermitant	Renewable	60.0

Effect on Grid

- Reduced Stability
- Increased Criticality
- Stressed Operations

SOLUTION

Capacity Firming

Energy Storage Systems

EXPECTATIONS

Carbon-free grid with Round-the-clock Renewables for all seasons

Required storage by 2030- Total 61 GW

PSP 19 GW / 128 GWh (6.7 hrs)

BESS 42 GW BESS + 208 GWh (5 hrs)

Source- NEP 2023

Long duration storage

RELEVANCE- Grid requirement daily and seasonal

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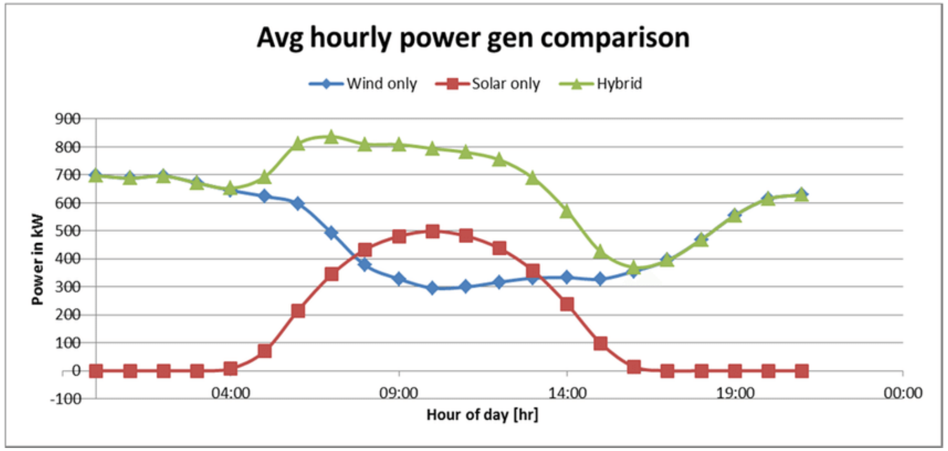
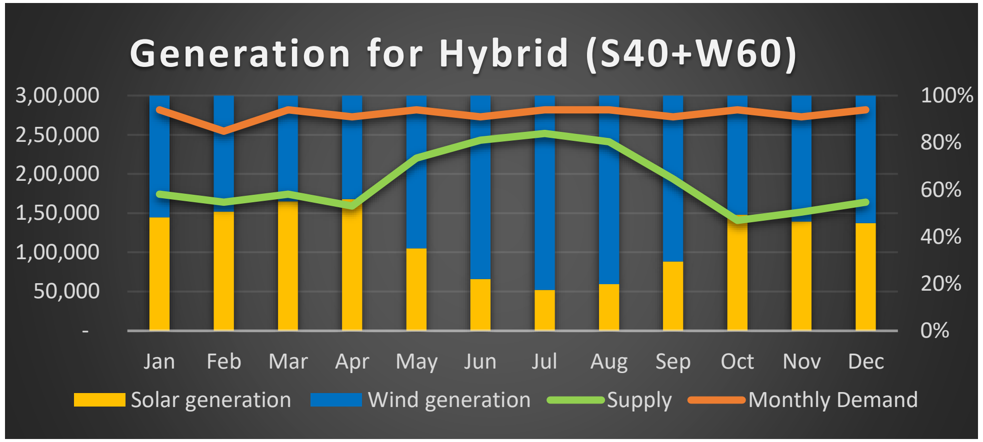
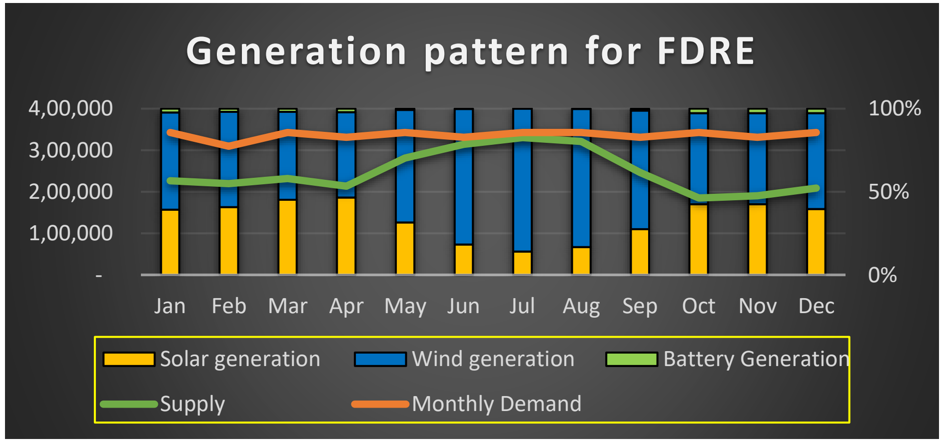




RTC

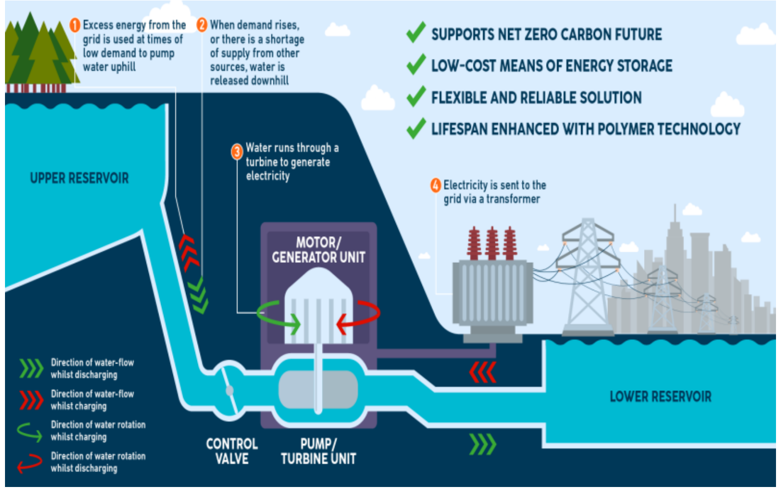
Other Sources																				BESS			
					Wind													Wind					
							Solar																
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23

	RTC	Hybrid	
Technology mix	Leveraging RE + ESS	80% RE 20% Other	51% RE 49% Thermal
Capacity utilisation	80%	85%	85%
Solar : Wind	30 : 70	40 : 60	30 : 70
RE capacity oversize %	225%	250%	~50%
Surplus generation	25-30%	30-35%	Very low
BESS component	100 MWh	Not included	Not included



LDES TECHNOLOGIES

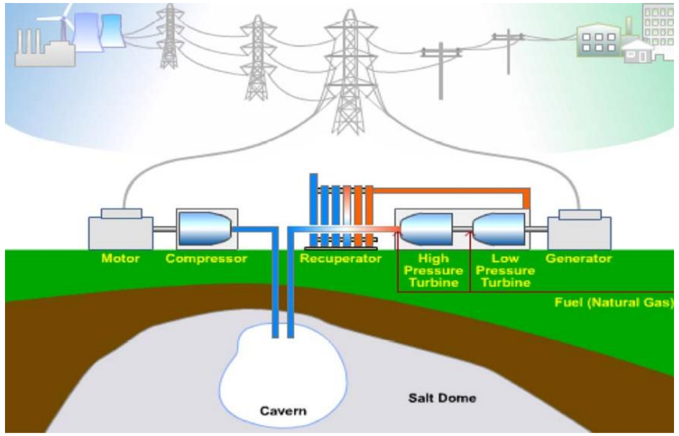
Pumped Storage



Advantages	Disadvantages
• High efficiency • Environment friendly • Suitable for Higher capacity storage • Flexible charging/ discharging • Very long life (40-50 years)	• High Capital cost • High construction time • Low energy density • Site specific-geography location

Pumped Storage Projects	Energy Storage Tech	Compressed Air Energy Storage
50 MW to 1000+ MW	Capacity (MW)	Upto 300 MW
hours to days	Discharge time (hours)	upto 24 hours
18,000 – 27000 in 50 Years	Life time (number of cycles)	1000 – 10,000
80%	Round-trip efficiency (%)	65-75%
35,000 - 55,000 / KW	CAPEX (₹)	88,000 – 112,000 /kW
3.91	LCOS* (₹/kWh)	3.58
120	GWP** (kg CO_2 eq/MWh)	160

Compressed Air Storage

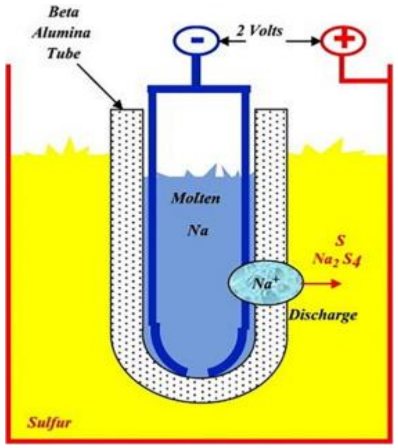


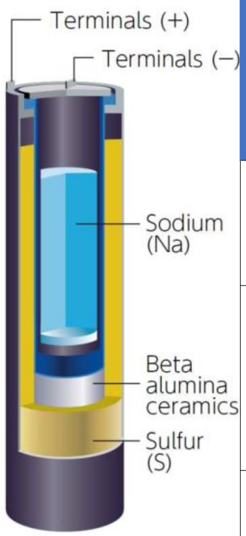
Advantages	Disadvantages
• Long duration • Suitable for Higher capacity storage • Flexible charging/ discharging • long life (25-30 years) • Uses Conventional synchronous machines	• High Capital cost • Construction Suitable Caverns • Low efficiency

SOURCE- Study Report on ESS by IIT Roorkee

LDES TECHNOLOGIES

NaS Battery

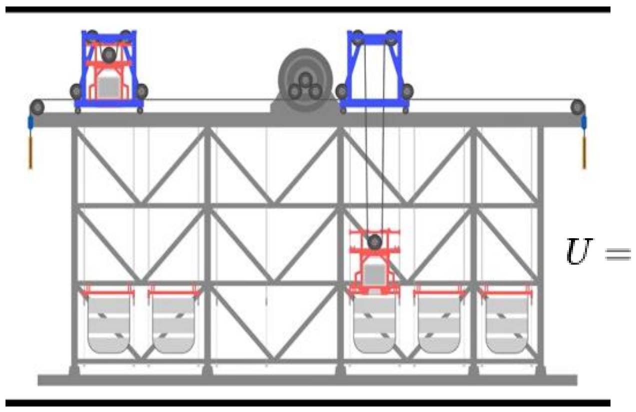




Advantages	Disadvantages
▪ Suitable for long duration 6-8 hour storage ▪ High life time ~ 20 years ▪ Fast response ▪ Environmentally friendly ▪ Modular and scalable	▪ A high temperature (350°C) requirement to liquefy the sodium leads to high operational cost. ▪ High Aux consumption 30 KW for 250KW /1450 KWh system ▪ Can be dangerous if the sodium comes into contact with air

Nas Storage Projects	Energy Storage Tech	LWS Storage
400 MW +	Capacity (MW)	Up to 100 MW
6-8 hrs	Discharge time (hours)	8 hrs
20 years	Life time (number of cycles)	40-50- years
70 %	Round-trip efficiency (%)	80-83%
-	CAPEX (₹)	-
-	LCOS* (₹/kWh)	-

LWS or Gravity Battery



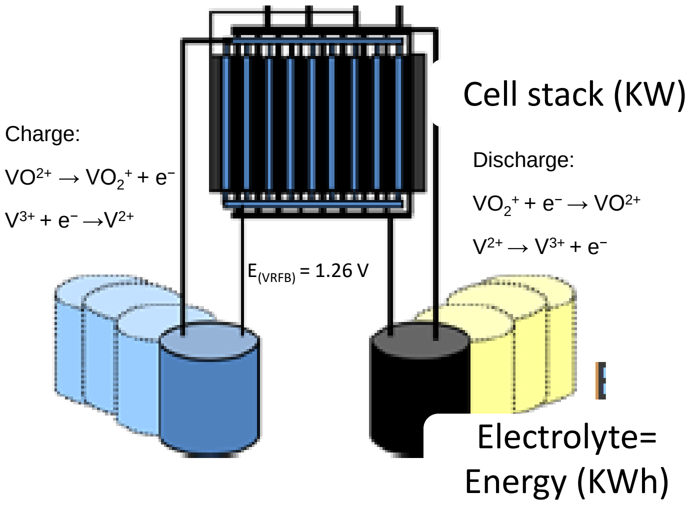
$$U = mgh$$

$$\Delta E = mg(h_1 - h_2)$$

Advantages	Disadvantages
• High efficiency • Environment friendly • Suitable for Higher capacity storage • Flexible charging/ discharging • Very long life (40-50 years)	• High Initial cost • Low energy density • Technology in R&D / Pilot stage

LDES TECHNOLOGIES

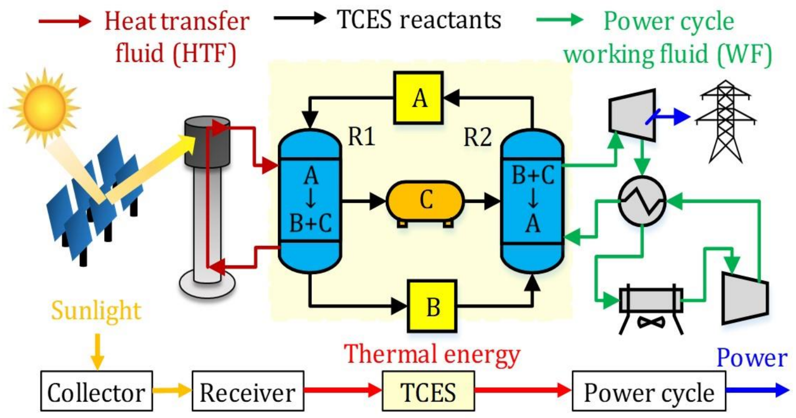
Flow Battery (Vanadium)



Advantages	Disadvantages
▪ Unlimited Cycles ▪ 100% DOD ▪ Temperature tolerance ▪ Safe ▪ Sustainable ▪ Modular and scalable	▪ Lower Efficiency ▪ Slow Response ▪ High upfront Cost ▪ Large Space requirements ▪ Not suitable for smaller application

Vanadium redox flow battery	Energy Storage Tech	Thermal energy storage
100 MW/400 MWh	Capacity (MW)	1010 MWh
4-12	Discharge time (hours)	Up to 16 hrs
7,000-10,000+	Life time (number of cycles)	20 to 25 Years
60-65 %	Round-trip efficiency (%)	70%
24,000 – 32000/kWh	CAPEX (₹)	240,000 /kW
11.52	LCOS* (₹/kWh)	8.65
190	GWP** (kg CO_2 eq/MWh)	185

CSP based thermal storage



Advantages	Disadvantages
▪ Conventional synchronous machines ▪ Sustainable ▪ Scalable ▪ High Potential in India	▪ Lower Efficiency ▪ High upfront Cost ▪ Space requirements

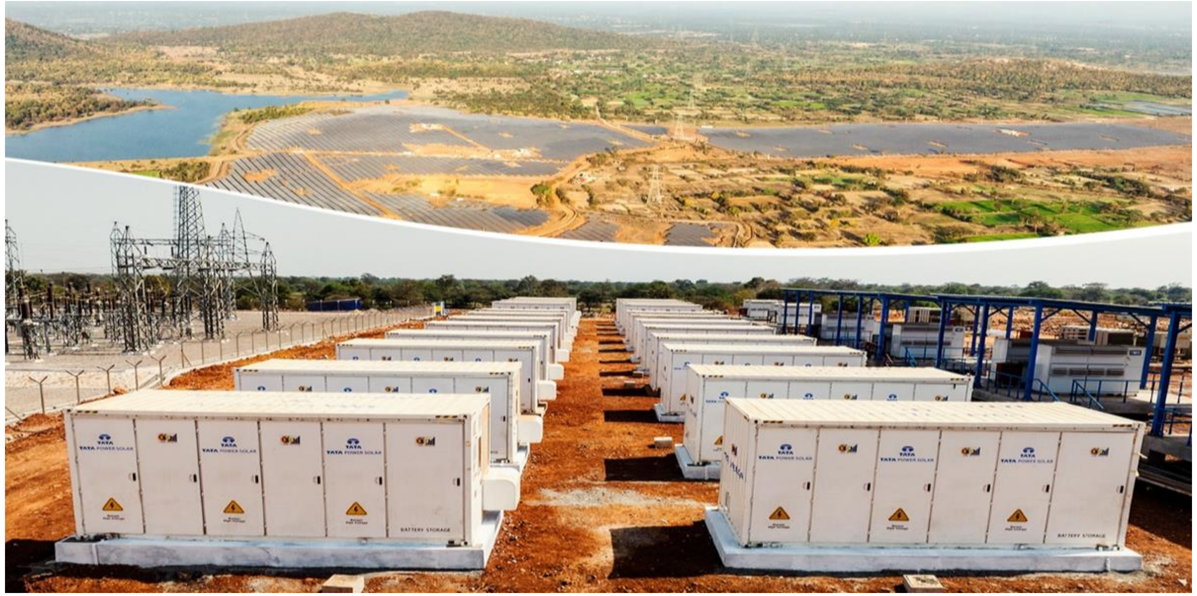
SOURCE- Study Report on ESS by IIT Roorkee

LDES TECHNOLOGIES- Comparision

Type of storage	Round trip efficiency	Initial Cost	Duration	Features	Applications
Pump storage	80%	Very High	6-8 hrs	Site specific, commercially available and proven technology, long life upto 50 years.	Peak shifting, capacity firming, Ancillary services
Compressed Air storage	65-75%	Very High	24 hours	Still under development, commercial viability yet to be proven,	Peak shifting, capacity firming, Ancillary services
NaS Battery	~ 70%	High	6-8 hrs	Long life of 20 years, High energy density, High Aux consumption.	Peak shifting
Vanadium Flow Battery	~ 70%	High	4 – 12 hrs	Unlimited life, Safe & Sustainable but slow response	Peak shifting
Gravity	~ 83 %	Low	8 hrs	Best efficiency, long storage duration, very long life (50 years), under development technology	Peak shifting
Li-Ion Battery	~ 94 %	High	2-4 hrs	High efficiency, stable chemistry, Quick response, good life cycle	Peak shifting + Ancillary services
CSP Thermal	~ 65 %	High	16 hrs	Long life of 20 years, High Potential Sites in India	Peak shifting, Ancillary services

CASE STUDY

100 MW Solar + 40MW /120 MWh BESS at Chattisgarh for SECI



PROJECT

BESS - 40 MW/ 120 MWh

C rate - 0.33 C

Cycle - 1 /day

RTE (AC) – 80%

Application - Peak Shift

Charge - Solar (120 MWac)

Discharge - Grid

Availability - 98%

CHALLANGES

- *New technology with limited know how*
- *1st time implementation at Utility scale*
- *Stringent Tender Requirements*
- *Unavailability of Indian Supplier*
- *Unavailability of Competency*
- *Site Challenges*

BEYOND 4 HRS

Hrs	C rate	RTE % (DC)
2	0.5	92.2
3	0.33	95.0
4	0.25	95.5
5	0.20	95.8
6	0.17	96.0

- Increase in Aux consumption
- Increase in DC-DC RTE
- Using higher DOD
- Requirement of additional battery packs

KEY TAKEAWAYS / RECOMMENDATIONS

- LDES are need of the hour for supporting Gird Requirements
- Current Dependency is on PSP and Lithium Batteries - have better efficiency
- Other LDES technologies
  - ➢ More R&D & pilots required
  - ➢ Improvement in efficiency
  - ➢ Policy framework to promote
  - ➢ Indianization of manufacturing
  - ➢ Establishing safety standards and process

THANK YOU

For discussions/suggestions/queries email: ***isuw@isuw.in***

visit: www.isuw.in

Links/References (If any)