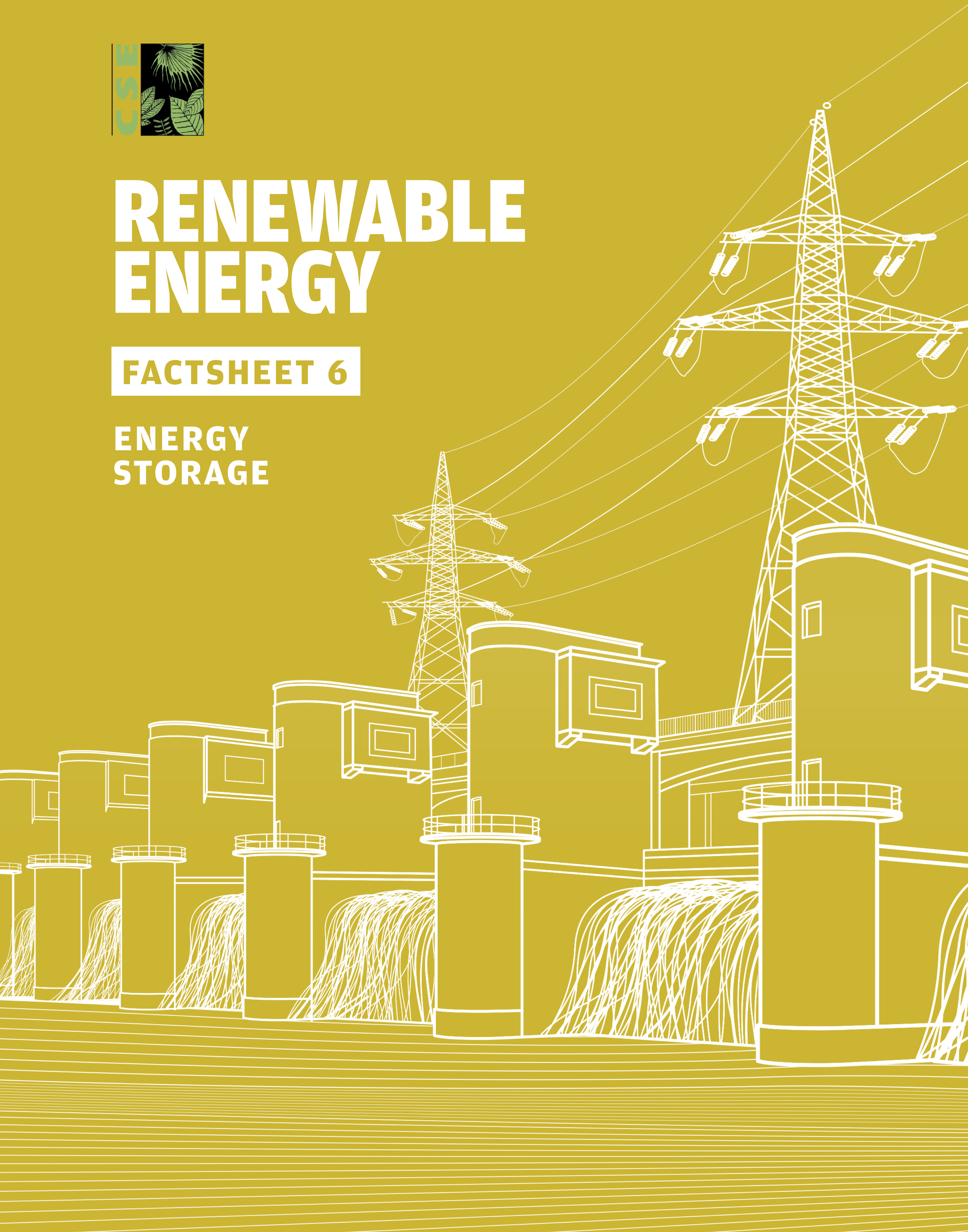
RENEWABLE ENERGY

FACTSHEET 6

ENERGY STORAGE



ENERGY STORAGE

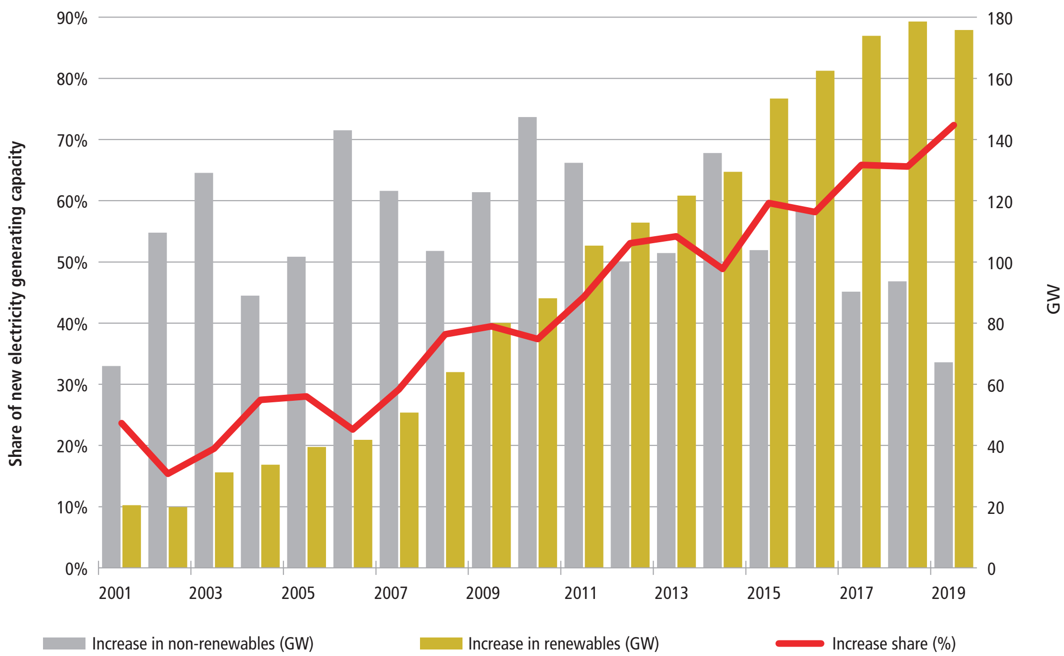
With renewable energy capacity addition outstripping that of coal globally, energy storage has acquired immense importance. India needs to develop its own domestic manufacturing capacity in this sector

A. APPLICATION AND GLOBAL INSTALLATION

A 1 Integration of RE generation

The world has been installing more renewable energy (RE) capacity than coal (*see Graph 1*). Of the 176 GW of total new RE installations in 2019, about 90 per cent has been solar and wind. Energy storage helps in the integration of solar and wind generation in the grid, as RE is variable – it is generated when the sun shines or the wind blows. With increasing RE capacity addition, the requirement for storage is also going up for ensuring reliable energy supply.

Graph 1: Renewable and non-renewable capacity addition and proportion of RE



Source: IRENA (2020), Renewable capacity highlights[1]

A 2 Role in grid balancing

Apart from RE integration, storage also helps in balancing the grid by increasing the flexibility of generation, controlling and managing frequency and voltage, providing ancillary services, managing the demand, and back-up the reserve through quick ramp-up and ramp-down mechanisms. This increases the resilience of the energy infrastructure. Different types of technologies (*see Box: Energy storage technologies*) are employed in providing these services. For example, in 2017, over 70 per cent of the global thermal storage was used for RE firming (*see Graph 2*).

Energy storage technologies

In an amendment to the National Wind-Solar Hybrid Policy, the MNRE broadened the definition of storage from 'the battery' to include the restricted use of other forms of storage such as pumped hydro, compressed air, flywheel, etc.[3] Some of these technologies are explained here:[4]

Pumped Hydro Energy Storage (PHES): Excess energy is used to pump water to a large reservoir at a higher elevation. When energy is required, the water in the reservoir is guided through a hydroelectric turbine, which converts the energy of flowing water to electricity. PHES is often used to store energy for long durations for use in future.

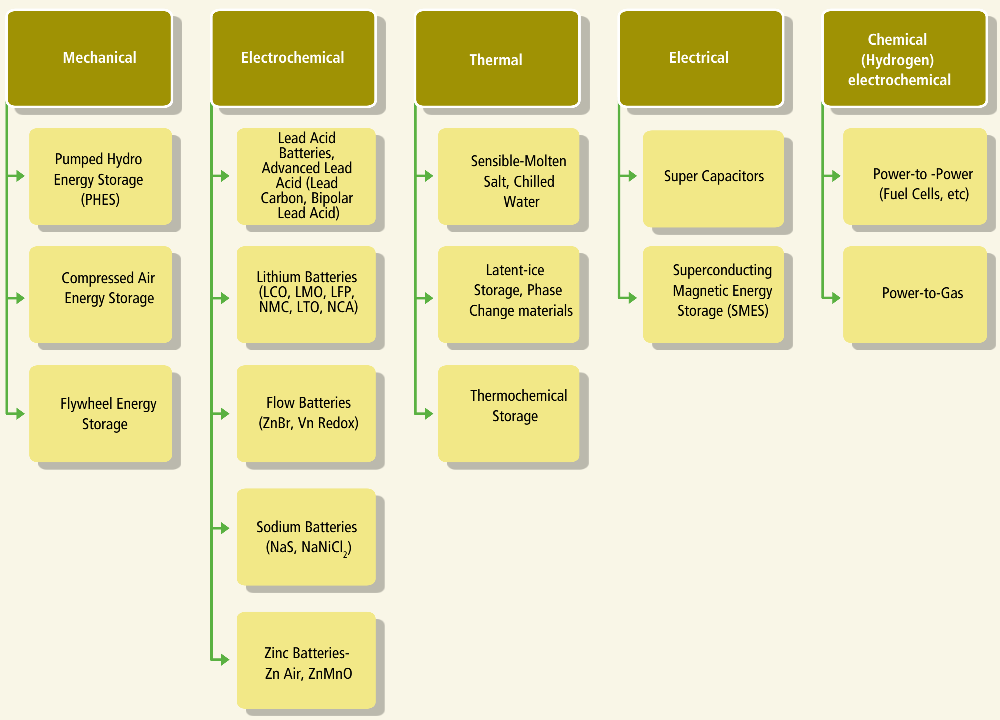
Electrochemical batteries: These use different chemical compounds to store electricity. The traditional solid rechargeable batteries store chemical energy in solid metal electrodes. The flow batteries store chemical energy in varying types of flowing liquid electrolytes kept in tanks separate from the actual electrochemical cells.

Compressed Air Energy Storage (CAES): Excess or low-cost electricity is used to run an electric compressor, which compresses the air, which is then stored either in an underground cave or above ground in high-pressure containers. When electrical energy is required, the compressed air is directed towards a modified gas turbine, which converts the stored energy to electricity.

Flywheel Energy Storage (FES): FES stores electrical energy as rotational energy in a heavy mass, typically a large rotating cylinder supported on a stator. In general, flywheels are very suitable for high power applications due to their capacity to absorb and release energy in a very short duration of time, mainly for frequency regulation applications.

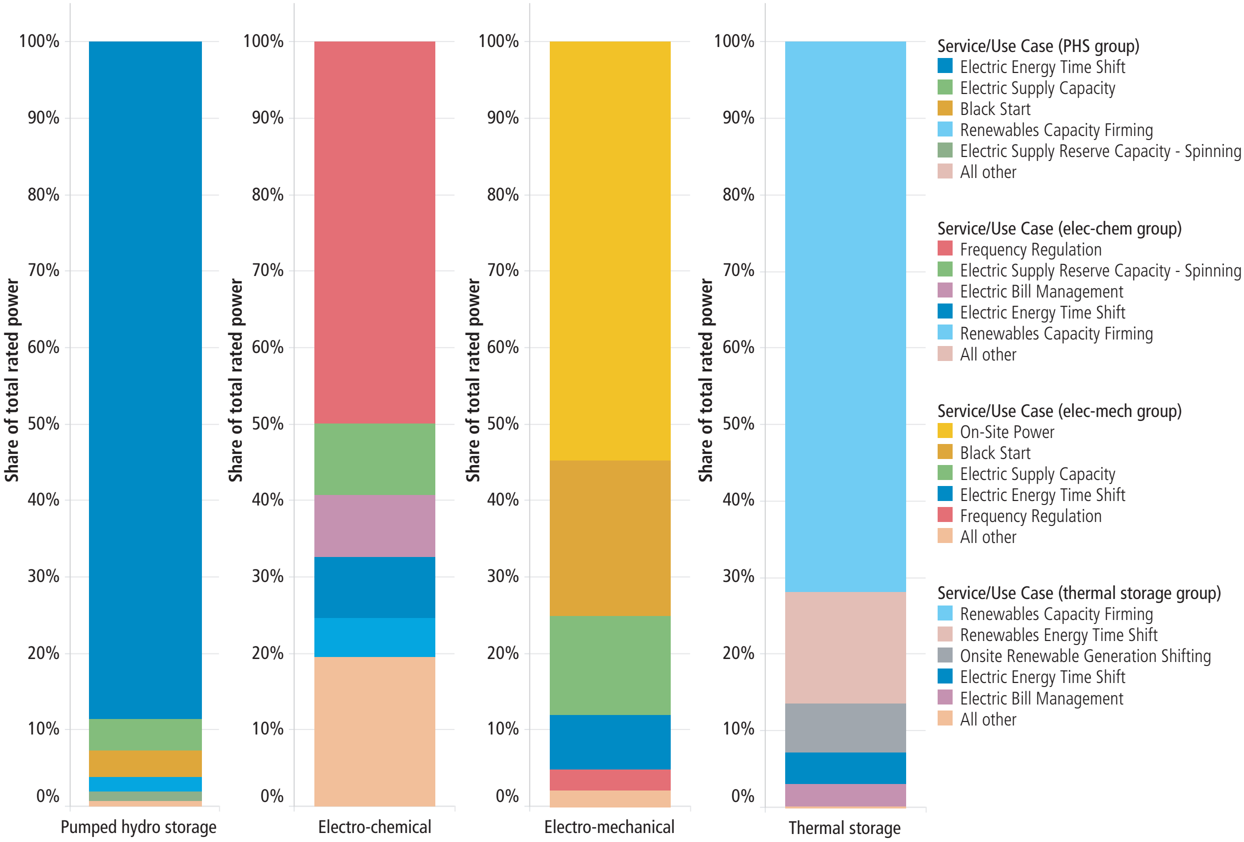
Molten salt: Excess available thermal energy is stored in the form of an increase or decrease in temperature of a material, which can be used to meet a heating or cooling demand. Molten salt storage is generally coupled with Concentrated Solar Power (CSP) plants.

Energy storage methods can be classified under five main categories:



Source: Niti Aayog Energy Storage System Roadmap for India 2019-2032

Graph 2: Global energy storage power capacity shares by main-use case and technology groups, mid-2017

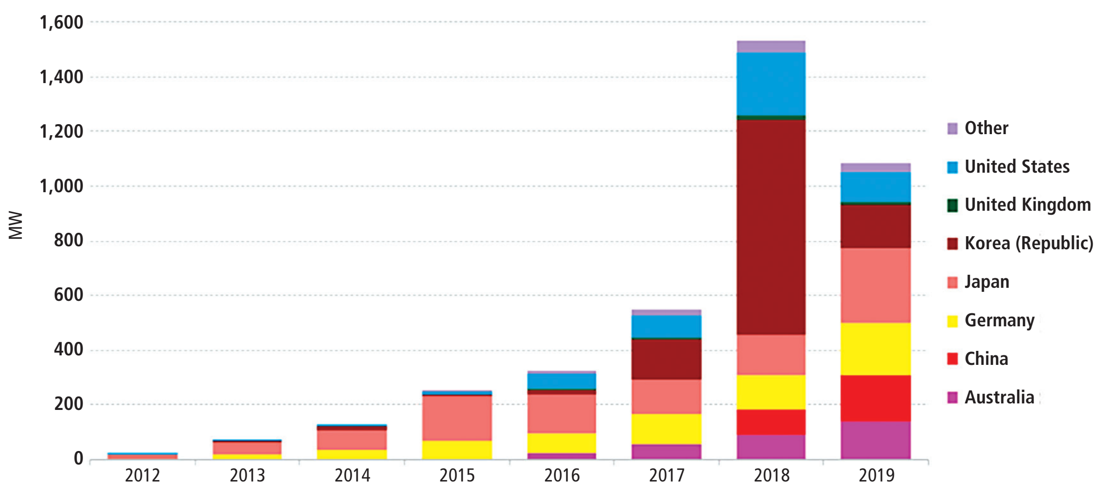


Source: IRENA Electricity Storage Costs 2017[5]

A 3 Behind-the-meter application

With increased penetration of decentralised solar, energy storage finds applications on the customer's side of the utility meter (*see Graph 3*). Major drivers include 'time of day' tariffs and subsidies, and the preference is largely for high density batteries.

Graph 3: Global yearly behind-the-meter (BTM) deployments

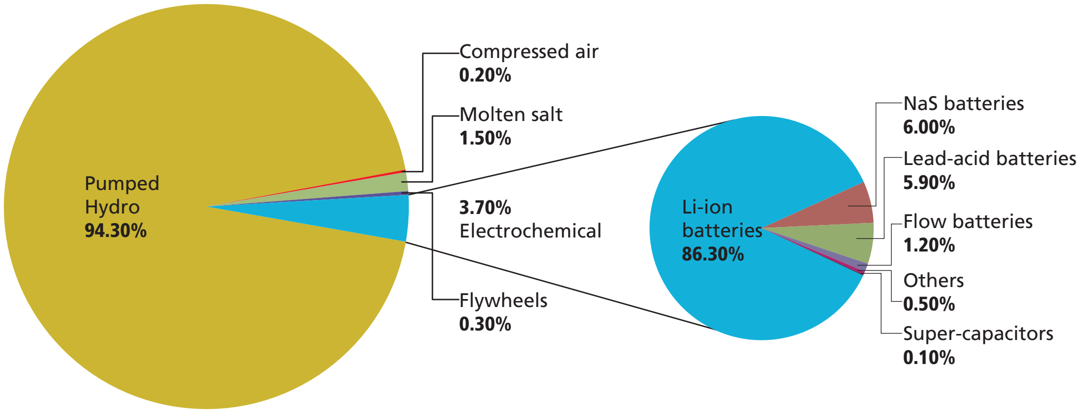


Note: Excludes pumped hydro and compressed energy projects
Source: Bloomberg NEF Energy Storage Market Outlook

A 4 Global operational energy storage capacity

According to the China Energy Storage Alliance (CNESA), the global operational energy storage capacity was about 180 GW by the end of 2018 (see Graph 4).

Graph 4: Accumulated global energy storage market capacity (2000-2018)



Source: CNESA Global Energy Storage Project Database[6]

B. STORAGE — PRESENT AND FUTURE

B 1 Major energy storage mediums — Pumped Hydro Energy Storage (PHES)

So far, PHES has been the cornerstone of all energy storage across the world. According to the IRENA, by 2030, the PHES capacity will increase by 1.5-2.4 TWh above the 2017 levels of 4.5 TWh. However, this will happen only if RE capacity doubles in that same period. But the other sources of storage have experienced better growth than PHES — which implies that the share of PHES in total world energy storage capacity (which is currently about 94 per cent), will slide down to 45-51 per cent in 2030.

India hosts 4.7 GW of operational PHES facilities (as per data obtained till March 2020), including projects like Srisailam in Telangana, Purulia in West Bengal, etc[7] (*see Table 1*).

Table 1: Status of PHES projects undertaken in India

Sl. No.	Status of various projects	Number of projects	Total capacity (MW)
1.	Operational - Working in pumping mode	6	3305.60
2.	Operational - Presently not working in pumping mode	3	1480
3.	Under construction	3	1580
4.	Detailed Project Report (DPR) concurred by CEA	1	1000
5.	Under survey and investigation	7	7380

Source: CEA Monthly Report Hydro Pump Storage, March 2020[8]

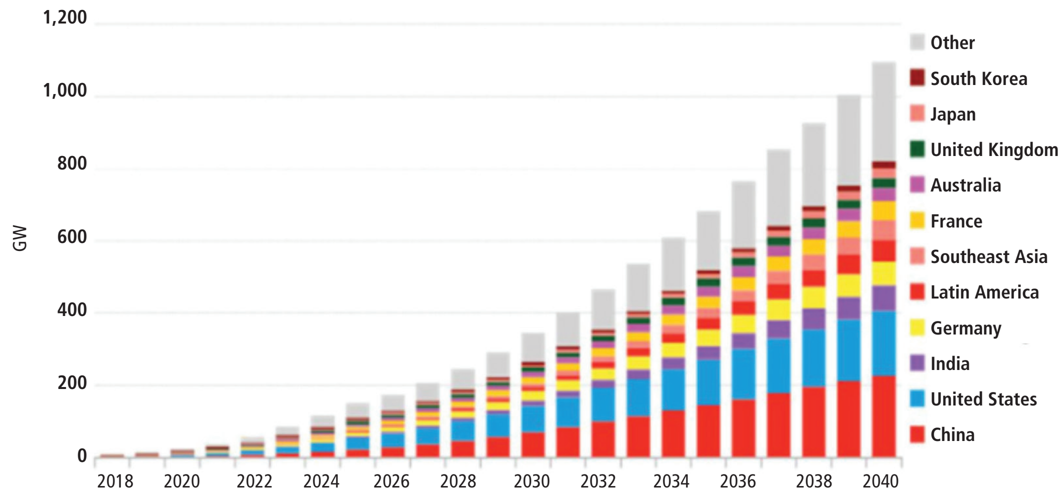
In a re-assessment study carried out by the Central Electricity Authority (CEA) during 1978-87, the pumped storage potential was identified as 96.5 GW (63 schemes) on the main rivers and their tributaries[9]. However, no new assessment is available. Other than technical issues of a long gestation period, normally because of sizeable civil work, the building-up of these systems in India are often marred by social and political challenges.

According to the Institute of Energy Economics and Financial Analysis (IEEFA), the PHES sector in India will require at least US $20 billion of new investments in the coming decade[10].

B 2 Growth in the battery segment

In 2018, the global market for the batteries was estimated at 9 GW / 17 GWh. Bloomberg New Energy Finance (Bloomberg NEF), a research company, forecasted that the global battery energy storage market will grow to a cumulative 1,095 GW / 2,850 GWh by 2040 (*see Graph 5*), attracting US $662 billion in investments since 2019 for the next 21 years[11]. This should be equivalent to 7 per cent of the world's total installed power capacity in 2040. The reasons for such hefty estimates are based on an unprecedented fall in the cost of the storage system, combined with a surge in attention for electric vehicles (EVs) and energy access for all.

Graph 5: Global cumulative battery energy storage deployments



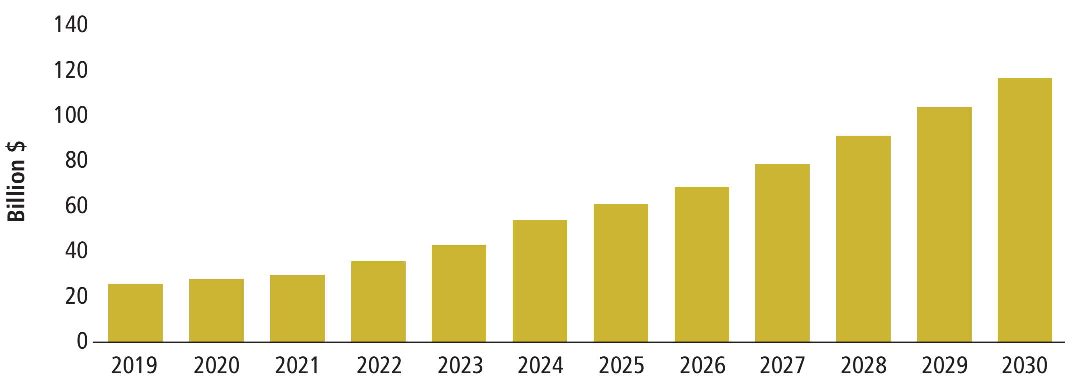
Source: Bloomberg NEF[12]

The World Bank, under its 'Accelerating Battery Storage for Development' programme, has committed US $1 billion to increase investments in battery storage for utilisation in RE integration, grid service applications, and developing mini-grids in low-access areas. It will mobilise another US $4 billion to boost the deployment of energy storage systems through a Global International Partnership.

B 3 Lithium-ion batteries (LIB) — the real game-changers

LIB prices, which were above US $1,100 per kWh in 2010, have fallen 87 per cent in real terms to US $156 / kWh in 2019. By 2023, average prices will be close to US $100 / kWh, according to the latest forecast from Bloomberg NEF (*see Graph 6*).

Graph 6: Annual lithium-ion battery market size



Source: Bloomberg NEF

C. THE INDIAN CONTEXT

C 1 The demand

The CEA model forecasts that India will need 34 GW / 136 GWh battery energy storage systems by 2030 to balance grid stability[14]. To achieve this, the NITI Aayog suggests development of 6 / 12 numbers of gigawatt-scale factories with 10 GWh capacity each by 2025 / 2030. It is in the process of finalising the Giga-Scale Lithium-ion Battery Manufacturing Programme in India. The battery energy storage cost in the country is estimated to reduce uniformly from Rs 7 crore / MW in 2021-22 to Rs 4.3 crore / MW in 2029-30[15].

C 2 The government's efforts

In March 2019, the Union Cabinet approved the National Mission on Transformative Mobility and Battery Storage that includes a five-year phased manufacturing programme to set up large-scale battery and cell manufacturing giga-sized plants in India[16]. However, the Mission has not taken off yet. The current storage market seems restricted to battery energy storage systems.

C 3 An energy storage roadmap

The NITI Aayog, in association with the India Smart Grid Forum (ISGF), has come up with an Energy Storage Roadmap for India 2019-2032, which includes the requirement of storage deployment for various applications in India (*see Table 2*).

Table 2: Consolidated energy storage requirement

	Consolidated Energy Storage Roadmap					
	Applications		Energy Storage (GWh)			
			2019-2022	2022-2027	2027-2032	Total by 2032
Stationary storage	Grid Support	MV/LV	10	24	33	67
		EHV	7	38	97	142
	Telecom Towers		25	51	78	154
	Data Centres, UPS and inverters		80	160	234	474
	Miscellaneous Applications (Railways, rural electrification, HVAC application)		16	45	90	151
	DG Usage Minimization		–	4	11	14
	Total Stationary (GWh)		138	322	543	1002
Electric Vehicle	E2W		4	51	441	496
	E3W		26	43	67	136
	E4W		8	102	615	725
	Electric Bus		2	11	44	57
	Total Electric Vehicles (GWh)		40	207	1167	1414
Total Energy Storage Demand (GWh)			**178**	**529**	**1710**	**2416**

Source: ISGF Energy Storage Roadmap for India 2019-2032

C 4 The SECI tenders and experiments

In India, the battery energy storage system (BESS) has been employed with small PV plants in the regions not strongly connected with the grid. In FY20, the Solar Energy Corporation of India (SECI) has tendered such small PV plants in the Andaman & Nicobar Islands, Leh (Kargil) and Lakshadweep Islands (floating solar). These are to be backed up with small-scale BESS of less than 60 MWh capacity.

In January 2020, the SECI successfully completed a one-of-its-kind 1,200 MW RE+ storage tender under the Inter-state Transmission System (ISTS). The projects implemented under this tender are required to provide assured firm energy throughout the day and meet peak requirements.

The tender received bids of Rs 4.04 and Rs 4.30, which are less than new coal tariffs that are in the range of Rs 5-7 (*see Table 3*).

Table 3: SECI's 1,200-MW renewable-cum-storage tender outcome

Normative capacity utilisation factor of 35 per cent is mandated

	Greenko Group	Renew Power
Awarded capacity	**900 MW**	**300 MW**
Peak tariff	**Rs 6.12**	**Rs 6.85**
Off-peak tariff	**Rs 2.88**	**Rs 2.88**
Effective weighted average tariff	**Rs 4.04**	**Rs 4.30**
Storage technology	**Pumped Hydro Energy Storage (450 MWh capacity)**	**Li-ion Batteries (capacity of 150 MWh)**

Source: SECI ISTS-RE with Peak Power 1,200 MW (ISTS-VII) result[17]

This is certainly an innovative packaging[18]. Successful implementation of the project may open up many opportunities.

C 5 Going forward — what needs to be done

India should not miss the opportunity of developing its own storage. The R&D for the development of different battery technologies in India should be prioritised to ensure that a domestic manufacturing ecosystem thrives and the country does not become import-dependent (as is the case with photovoltaic panels).

Batteries have lifetimes of three-10 years depending on the chemistry involved. A proper regulatory framework is required to streamline the recycling process and disposal of batteries so that environmental impacts are minimised.

In parallel, India should keep strengthening its biomass sector which can play a balancing role, instead of shifting the reliance on to chemical batteries, especially LIB. The raw material for the former is readily and easily available, unlike the latter. Also, the end-cycle product in the latter case is not environment-friendly.

References

1. IRENA (2020), Renewable capacity highlights, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Mar/IRENA_RE_Capacity_Highlights_2020.pdf?la=en&hash=B6BDF8C3306D271327729B9F9C9AF5F1274FE30B
2. https://niti.gov.in/sites/default/files/2019-11/ISGF.pdf
3. MNRE Amendment in National Wind-Solar Hybrid Policy - Reg. dt. 13.08.2018, https://mnre.gov.in/img/documents/uploads/41e72559eb1140d18ad1a082ec050426.pdf
4. https://niti.gov.in/sites/default/files/2019-11/ISGF.pdf
5. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2017/Oct/IRENA_Electricity_Storage_Costs_2017.pdf
6. https://static1.squarespace.com/static/55826ab6e4b0a6d2b0f53e3d/t/5d15c6faa4a909000140d50f/1561708291553/White+Paper+Summary+2019+-+English+Version.pdf
7. http://www.cea.nic.in/reports/monthly/hydro/2020/pump_storage-03.pdf
8. http://www.cea.nic.in/reports/monthly/hydro/2020/pump_storage-03.pdf
9. http://www.cea.nic.in/reports/others/planning/resd/mom_pump_storage_plants.pdf
10. https://ieefa.org/wp-content/uploads/2019/03/IEEFA-India_Pumped-Hydro-Storage_Mar-2019.pdf
11. https://about.bnef.com/blog/energy-storage-investments-boom-battery-costs-halve-next-decade/
12. https://about.bnef.com/blog/energy-storage-investments-boom-battery-costs-halve-next-decade/
13. https://about.bnef.com/blog/battery-pack-prices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/
14. http://cea.nic.in/reports/others/planning/irp/Optimal_generation_mix_report.pdf
15. http://cea.nic.in/reports/others/planning/irp/Optimal_generation_mix_report.pdf
16. https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1567807
17. https://seci.co.in/web-data/docs/SECI%20ISTS-RE%20with%20Peak%20Power%201200%20MW%20(ISTS-VII)%20result%20website%20upload.pdf
18. https://www.downtoearth.org.in/blog/energy/will-the-recent-seci-bid-help-unlock-the-complete-potential-of-renewable-energy--69884

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