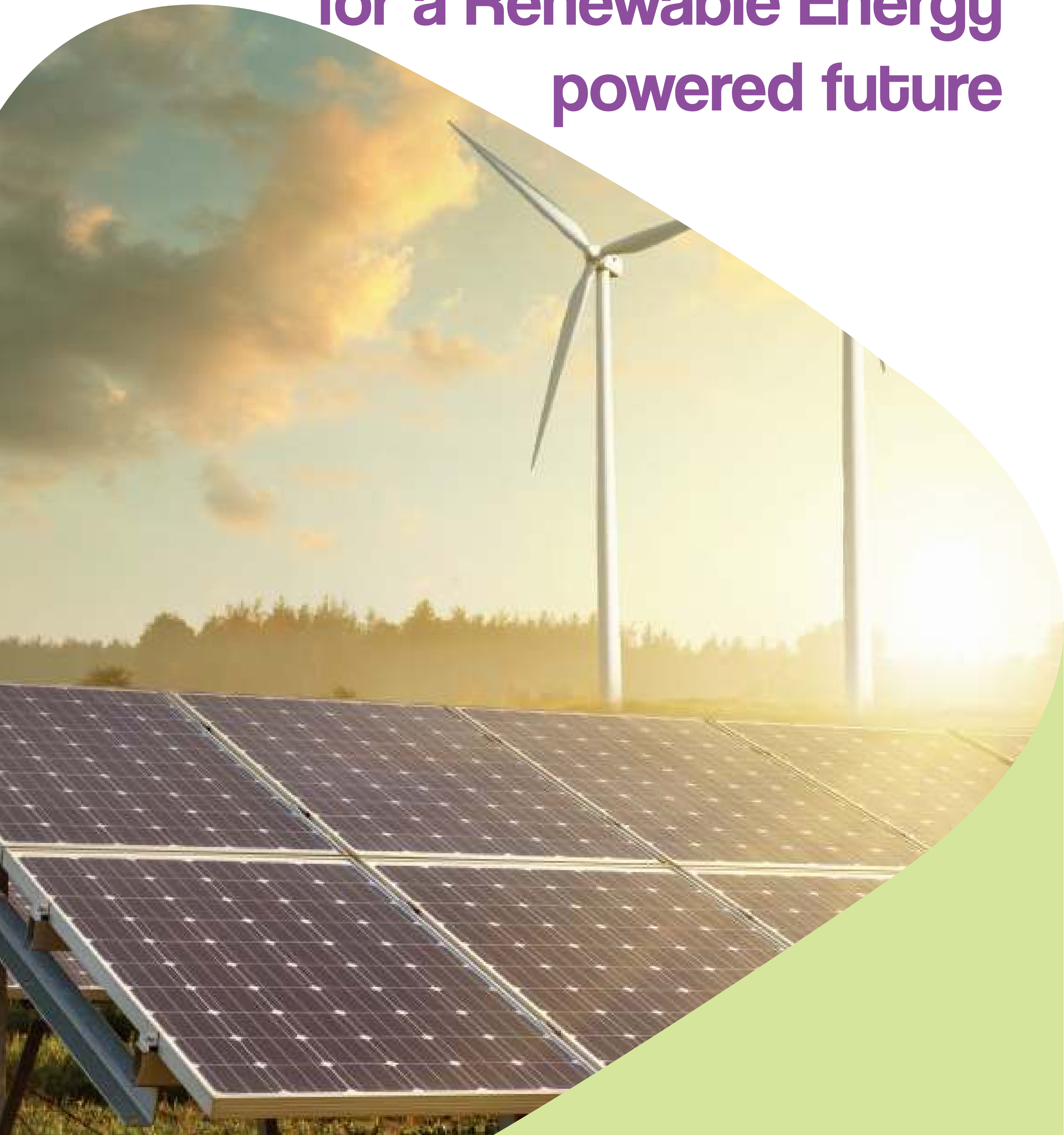
I E T P

India Energy Transformation Platform

Decarbonising India

New Technology Options for a Renewable Energy powered future



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Knowledge partner: KPMG Advisory Services Pvt. Ltd. and Carbon Trust

Secretariat: Center for study of Science, Technology & Policy

Supported by: Shakti Sustainable Energy Foundation and Swiss Agency for Development & Cooperation

1 About IETP

The India Energy Transformation Platform is an independent, multi-stakeholder group of experts aiming to develop an informed narrative on India's strategies for meeting its Nationally Determined Contributions (NDCs) through non-linear, transformative solutions. This unique initiative, jointly conceptualised by Center for study of Science, Technology & Policy (CSTEP) and Shakti Sustainable Energy Foundation (SSEF), hopes to ensure that India stays ahead of the curve and cements its leadership in the global transition to clean energy – even beyond 2030. Over the past year, the platform has supported research across four themes - decentralised energy systems, renewable energy dominant electricity system, industrial process heat, and urban cooling demand- exploring novel technology options to help develop low-carbon energy pathways up to 2050. The project teams (under each theme) have undertaken rigorous study and have thus put forth their results and recommendations in the form of the following policy brief.

2 Key Recommendations

With India's ambition of moving towards a RE dominant future and achieving ~450 GW of RE by 2030, higher flexibility in the power system will become necessary. Storage solutions, which are easy to implement, contribute to country's economic growth and utilise in-house resources need to be explored, promoted, and deployed going forward. With this objective, key recommendations to enable new storage solutions to bring in needed flexibility in the system in the future are as follows:

- Develop roadmap for concurrent deployment of complementary storage solutions including pumped storage, power to hydrogen as well as batteries
- Standard guidelines for procurement of storage

solutions

- Mandate profitable Central Public Sector Undertaking (CPSUs) companies to invest certain percentage of turnover for R&D – technologies to be selected by Ministries.
- Focus on demand and infrastructure creation support for new age emerging technologies such as hydrogen.

As a part of the study, technologies including power to hydrogen, vanadium redox flow batteries (VRFB), and pumped hydro storage were identified as some of the promising technologies for India. The assessment considers the resource availability and demand for the above -mentioned technologies. Policy recommendations for development and implementation of these technologies are listed in the table below.

Technology	Focus area	Policy recommendations
Power to hydrogen	Demand creation	• Mandates for blending of hydrogen in CNG fuel (H-CNG) to be used in heavy-duty vehicles • Pilot scale implementation of fuel cell electric vehicle buses
	Infrastructure development for hydrogen storage and transport	• R&D projects to design and implement cost-effective hydrogen storage technologies • Encourage co-operation between companies such as SECI, GAIL and NTPC for pilot scale electrolyser installations powered by RE
	Access to low cost financing	• Expand hydrogen corpus fund through contribution for PSUs producing hydrogen from fossil fuels • Facilitate access to low-cost financing from Power Finance Corporation (PFC) and Rural Electrification Corporation (REC) for commercial implementation of hydrogen infrastructure
Vanadium redox flow battery	Supply side interventions	• Incentivise domestic industries such as alumina refining to recover vanadium from process waste • Incentivise domestic mining companies to mine vanadium ores for domestic manufacture of electrolyte
	Demand side interventions	• Enable battery storage systems to stack revenue from multiple sources – including participation in wholesale markets • MNRE may mandate battery storage systems for large solar parks
Pumped hydro storage	Land acquisition and clearances	• Set up committee with representatives from Central and State Govt. to facilitate land acquisition • Identify potential sites for setting up pumped hydro storage plants as regional 'balancing asset' close to existing large RE generation sources
	Market enablement	• Pumped storage could also be treated as a transmission asset operated by the transmission companies • Ministry of Power and MNRE should standardise long-term contracts for multiple states to access a regional storage asset • MNRE could provide standardised bidding documents for inviting tenders for renewable energy projects combined with long-term storage facilities such as pumped hydro

3 Rationale

India has more than doubled its installed renewable energy capacity since 2014 and currently accounts for nearly 35%[1] of total installed power generation capacity[2]. India targets to increase this to about 40% by 2030[3] and the share of RE in total power generation capacity may increase to over 80% by 2050[4]. Further, achieving these goals would also require decarbonisation of sectors, such as transport, that are traditionally fuelled by fossil-fuel sources. This change is nothing short of a paradigm shift and India's energy sector is going through a transition to align with a RE-dominant power system. The objective of this study is to identify technologies that are key to achieving an integrated RE dominated energy system by 2050 and develop pathways for these technologies to be developed, commercialised, and scaled-up.

Current policy scenario

Storage technologies and sector coupling are two key solutions that are imperative for making the system flexible.

Policy scenario for storage technologies

- Grid-scale energy storage installations in India are almost entirely in the form of pumped hydro projects. India has nine pumped hydro storage projects with 4.8GW capacity and two projects are currently under construction, with four more under development
- India's battery storage market is driven by lead-acid batteries used for residential back-up systems. The deployment of large-scale battery energy storage projects in India started in 2017 with Power Grid Corporation Limited (PGCIL) installing its first pilot for frequency regulation
- Several grid-scale battery storage projects, primarily based on lithium-ion chemistry, are now under development across the nation

Policy scenario for sector coupling

- At present, most of the focus on renewable energy is in the power sector, while efforts in end-use sectors are primarily concentrated around improving energy efficiency.
- Sector coupling, through electrification of sectors such as transport, building heating, is a key solution to achieve the twin goals of power system flexibility as well as reduction in carbon emissions.
- Currently, the transportation sector is leading this transition towards electrification. India has set a target of having 30% electric vehicles in its overall fleet by 2030. While, Li-ion battery systems have seen a promising start, they still face the challenge of import dependency.
- Hydrogen presents an attractive alternative to Li-ion battery powered electric vehicles. Hydrogen powered fuel cell electric vehicles (FCEV) offer critical advantages such as longer mileage, significantly shorter refuelling time, and energy security compared to Li-ion batteries.
- Further, power to hydrogen technologies supported through sector coupling can aid multi-fold gains for Indian energy sector both in form of an effective storage medium for RE as well as green fuel for other allied sectors such as metals, transport, industrial chemicals etc.

1 Including large hydro
2 Source: https://mnre.gov.in/physical-progress-achievements
3 Source: https://economictimes.indiatimes.com/industry/energy/power/renewables-to-account-for-55-of-energy-mix-by-2030-minister/articleshow/72020507.cms?from=mdr
4 Source: Shakti Foundation, IETP

4 Findings

As part of this study, 27 different technologies across generation, sector coupling, and storage were considered and top three technologies were shortlisted, considering the needs of India's power system and India's in-house potential of developing and utilising these technologies. A three-stage evaluation process was used to rate the technologies. The first two stages were used to shortlist the technologies based on inherent technical characteristics and the ability to be deployed in India. In the third stage, the shortlisted technologies were compared based on the utility each technology offers to the system.

The nature of storage system required at various levels for RE integration was established through a modeling approach. For the modelling approach adopted at the state level, it was observed that depending on the load profile and RE generation potential in the state, both short-duration as well as long-duration storage solutions may be required for different states. The magnitude of storage requirements across states may vary, however, the nature and flexibility characteristics of storage solutions is likely to remain the same. Technology such as battery storage offer short-term storage with quick response times while pumped hydro offers long-term storage with relatively longer response times. Such complementary technologies will have to be deployed concurrently for efficient integration of renewable energy into the power system. Among competing battery technologies considered, flow battery is the best alternative given its technical properties and availability of resources in India.

Approach

The approach to developing policy recommendations involved understanding the current status of deployment for each shortlisted technology and issues/bottlenecks hampering its growth. The following paragraphs briefly describe the rationale behind each recommendation.

Develop roadmap for concurrent deployment of complementary storage solutions including pumped storage, power to hydrogen as well as batteries

A detailed plan for deployment of various storage options is required to guide investments in technology development as well as commercial deployment (in case of mature technologies).

- *Battery storage:* As a mature technology, Li-ion may address current storage needs, but may exacerbate India's energy-security woes. Battery storage solutions such as vanadium redox flow batteries could be developed as a grid-scale storage alternative. This technology offers several advantages such as long life with negligible degradation of electrolytes and electrodes, operational safety, and flexible design. Additionally, these batteries also eliminate reliance on imports and can be manufactured indigenously.
- *Power to hydrogen:* For such new technologies, the roadmap could also provide detailed timeline and pathway for technology commercialisation. Currently, hydrogen is produced using fossil fuels, predominantly for use in fertilisers and oil refining industries. In India, FCEV is at the cusp of commercialisation, with vehicle models being launched and more expected in the short-term. In this context, the short-term focus should be on increasing the use of hydrogen as a transport fuel.
- *Pumped Hydro storage:* A re-assessment of the potential for pumped storage hydro power stations may be done and specific sites to future development of pumped storage projects need to be identified and pre-feasibility report of the same may be prepared. Capacity development targets for pumped storage may also be prescribed to bring in investment clarity to investors.

Standard guidelines for procurement of storage solutions

- Policies enabling efficient utilization of storage assets are required to ensure its economic viability. Detailed tariff/compensation structures are required for various services provided by storage systems such as load shifting, frequency regulation, voltage regulation based on system requirements.
- Policy measures to distribute the capex investment among multiple stakeholders could incentivise installation of storage systems. These systems could also be treated as transmission assets and their costs could be recovered as part of transmission charges.
- In the case of pumped hydro, alternate ownership models may also be adopted with the Government taking over site evaluation and land acquisition process while private entities/PSUs involved only in building the asset. This would help lowering the risk for private entities and thereby improving access to financing.
- New contracting options could be introduced, such as bundling RE generation with a suitable storage asset to providing round the clock power supply.

Mandate profitable CPSUs to invest certain percentage of turnover for R&D in technologies to be selected by Ministries/Niti Aayog

- Public sector undertakings could be used to fund research efforts into new technology options. For example, in the case of hydrogen, the Ministry of Petroleum and Natural Gas set up such a fund with a corpus of INR 100 crores with contribution from Oil Industry Development Board (OIDB) and oil PSUs to support research and development in hydrogen as an auto fuel

- This corpus was used to conduct research with collaboration from automakers and international agencies. As a result of the research efforts, Indian Oil R&D set up the country's first hydrogen refuelling station. This model could be expanded and implemented as an investment policy to ensure continued focus on new technology development
- Meanwhile, in the short term, investments should focus on R&D for lowering the cost of electrolysers. In the medium term, funding would be required for setting up electrolyser demonstration projects to produce green hydrogen. This can be undertaken through the corpus fund from various CPSUs
- A start-up-dedicated corpus may be set-up by CPSUs which will focus on aiding start-up ideas related to energy sector. Post successful demonstration of technology operations and a minimum scale of commercialisation, the start-ups can be further merged within the company structure by PSUs operating in the given domain

Focus on demand creation for new age emerging technologies such as hydrogen

Sustained demand for new technologies/solutions can be better achieved through market creation than through subsidies. In the case of hydrogen, a phased approach could be adopted to transition diesel-powered heavy-duty vehicles into hydrogen powered FCEVs. As a first step, in cities with existing fleet of CNG buses, policy mandating blending of hydrogen in CNG fuel (H-CNG) should be introduced. Meanwhile, in the short term, investments should focus on R&D for lowering the cost of electrolysers. Growth in demand for hydrogen as a fuel coupled with technology development would push the industry towards commercialisation of power to hydrogen infrastructure.

5 Conclusion

India is currently the third largest in terms of greenhouse gas emissions, only behind China and the US. India must integrate more RE into its overall energy sector to meet its intended Nationally Determined Contribution. By 2030, India targets to lower emissions intensity of its GDP by 33-35% compared to 2005. Achieving this milestone would require integrating RE into power as well as other sectors such as transport which are the largest consumers of fossil fuels. Storage systems and sector coupling technologies would play a critical role in enabling this transition to a RE dominant future. By 2032, the cumulative demand for energy storage systems in India is expected to be over 2,700GWh[5]. Given the scale of demand, there is a pressing need for domestic development of these solutions. The key challenges lie in enabling indigenous manufacturing and deepening power markets to create revenue sources for these technologies. Therefore, policy push should focus on creating an ecosystem that facilitates end to end deployment of new technologies.

5 India Smart Grid Forum, Energy Storage Roadmap for India, 2019

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