RENEWABLE ENERGY

ENERGY STORAGE

BEHIND-THE-METER AND ELECTRIC VEHICLES

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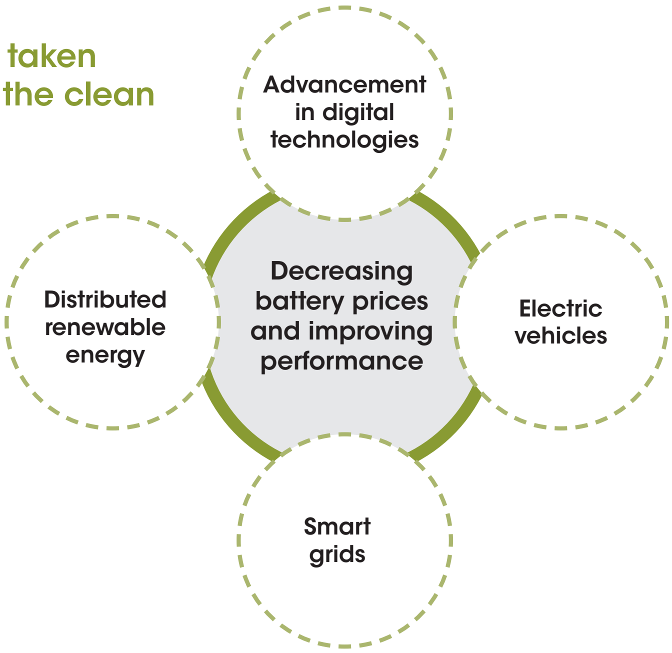
Overview

In the recent past, a slew of technological advancements and maturing of renewable energy (RE), particularly wind and solar, have signalled the next stage in the clean energy transition. This has been helped along by a rapidly evolving transportation section and the adoption of electric mobility. Energy storage has taken the centre stage in this transition. It can help address the intermittency of solar and wind power. In many cases, it can also respond quickly to large fluctuations in demand, making the grid more responsive and reducing the need for backup power plants. Energy storage also addresses growing concerns about the environmental impact of fossil fuels and the capacity and resilience of energy grids around the world.

The clean energy transition now requires co-evolution of innovation, investment and deployment strategies for emerging energy storage technologies. An energy storage revolution will bring about a paradigm shift in how we produce and use energy.

Energy storage has taken the centre stage in the clean energy transition



Source: CSE

There are two main methods for deploying and using energy storage technologies. The first is the 'front-of-meter' approach implemented at the utility scale, wherein the energy storage system is connected to the transmission or distribution network to ensure grid reliability. This happens on a considerably large scale. The other method is termed 'behind-the-meter' (BTM) and is implemented at the residential and commercial and industrial (C&I) levels, mainly to provide backup during power failures or to store excess locally generated energy from solar rooftop photovoltaic (PV) systems. Electric vehicles can fall into either category depending on various factors, including the kind of charging infrastructure available. BTM can be used by individuals at home or at a larger specialized charging facility.

The roundtable

The work of the Renewable Energy programme of Centre for Science and Environment (CSE)'s has been focused on shaping policies and building public awareness to accelerate renewable energy deployment, strengthen energy access for the poor, and facilitate creation of opportunities for people for making the best use of RE technologies. As part of its continuing efforts to highlight important issues concerning energy security and energy sustainability in India, CSE planned a series of nine stakeholder roundtables, held in 2020–21.

This roundtable, on energy storage, was the fourth in the series. It discussed opportunities in deploying behind-the-meter storage applications considering aspects of circular economy (recycling and disposal). Key speakers at the roundtable were:

Mr Samrat Sengupta

Director, Climate Change and Renewable Energy, CSE

Samrat is a development and operations management professional with 24 years of experience in sustainable energy and climate change cross-sectoral domains. His specific interests include renewable energy power projects, low carbon development and mainstreaming climate change in developmental planning. He has worked with power producers (solar, onshore and offshore wind, and hydro), management and engineering consulting houses, international trade associations for renewable energy promotion, national and international civil society organizations, and government research institutions. Samrat holds an MBA with a specialization in energy management from the Indian Institute of Social Welfare and Business Management (IISW and BM), Calcutta. He has also represented Indian and South Asian civil society in various multilateral forums like the UNFCCC, IPCC and G8.

Mr Sengupta moderated the Roundtable.

Dr Rahul Walawalkar

President, India Energy Storage Alliance (IESA)

Dr Walawalkar leads the emerging technologies and markets practice for Customized Energy Solutions (CES), an organization focused on energy storage, renewables, demand response and smart grid technologies. He is the founder and president of IESA and is the chair for the Global Energy Storage Alliance (GESA). He regularly advises governments in the US and India on smart grid, demand response and energy storage policies. Rahul holds a PhD in engineering and public policy from Carnegie Mellon University and a masters in energy management from New York Institute of Technology. Rahul has been recognized as a Legend in Energy by Association of Energy Engineers, US. In 2018, he was also awarded India Smart Grid Forum President's Award for his contribution for growth of smarter grids in India.

Mr Krishan Kumar Tiwari

R&D and Product Head, Sonalika Group

Mr Krishan Tiwari, is an R&D professional with more than 20 years of experience in the field of tractors and agricultural mechanization. He has worked with leading Indian manufactures of tractors. He is also a member of various legislative committees on tractor and agricultural machinery certification. His areas of expertise are product development, product marketing, agricultural operation and agricultural machinery certification. Mr Tiwari is an alumnus of Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur and has an M. Tech. in farm machinery and power.

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Mr Anant Jain

Founder & CEO, eBik

Mr Anant Jain has about a decade-worth of experience in projects ranging across hydro, solar and wind power and energy transmission. After ample exposure to the dynamics of the power sector, he started his own venture in the EV industry, developing affordable bicycles for the Indian market, an innovation for which he has been awarded a patent. Currently, he is working on multiple products in the EV space to make mobility affordable for millions.

Ms Swagata Dey

Deputy Programme Manager, Clean Air, CSE

In her role at CSE, she has been involved in developing Clean Air Action Plans and Graded Response Action Plans for cities under the National Clean Air Programme. Additionally, she has worked on developing sector-specific strategies for combating vehicular and industrial air pollution. At present, she is working on developing a roadmap towards a circular economy for EV batteries. Swagata holds a research-based MS from the Ohio State University, Columbus, US and an MSc in environment sciences from TERI University, New Delhi.

Mr Ashish George

Programme Manager, Renewable Energy, CSE

Ashish has over ten years of professional experience in the fields of renewable energy and energy access. His work has focused on providing analytical and strategic support, project development and programme management. He has worked on evaluating policies and regulations, preparing feasibility studies, strategy papers, roadmaps and policy briefs for state and national governments in India. He holds a BSc in physics from Loyola College, Chennai, and an MSc in environmental management from the Yale School of Environment, New Haven, Connecticut, US.

Agenda and discussion

Energy storage applications and EVs are riding on a wave of substantial growth, driven by plummeting lithium-ion prices. This has catalyzed innovation, investment and deployment strategies in many other emerging energy storage technologies. Lithium-ion battery storage continues to be the most widely used, making up the majority of all new capacity installed.[1]

The deployment and use of small-scale BTM batteries in power systems is picking up all over the world, due to the falling cost of battery storage technologies, a growing consumer market (including electric vehicles or EVs), and the proliferation of distributed RE systems (such as rooftop solar and mini-grids) and smart grids. Additionally, advancements in digital technologies, such as artificial intelligence, blockchain and predictive analytics, are giving rise to aggregated solutions and innovative business models. Start-ups around the world are commercializing intelligent networks of BTM batteries to benefit electricity customers, utilities and grid operators. All of these are mutually reinforcing mechanisms extending beyond just improvements in battery performance and cost, making the sector extremely dynamic.

Today, the most prevalent form of BTM applications (on the consumer side) starts with addressing issues like resilience and energy security on a local level by deploying UPS systems and shielding the consumer from increasing diesel prices. BTM is also popular with mini-grids. In future, it is expected that concepts like demand aggregation (which is a grouping of consumers or households with battery storage that can act as a single entity with the help of an aggregator) will become a reality and that regulations will evolve to allow participation of individual households in the electricity market or in the sale of battery-related services to grid operators.

There are two key forms of demand aggregation:

» Load shifting to enable real-time shifting of C&I loads to provide demand-side management services to grid operators. This makes a business case for deferred investments in distribution and transmission grid infrastructure.

» Local flexibility providing aggregators freedom at the distribution level. The role of aggregators can be vital to enable demand-side flexibility, especially in the residential sector, since residential customers are typically small actors whose priority is to have a reliable and cheap service with the least possible effort. Aggregators would allow the participation of these customers in different services without requiring them to monitor the market continuously. The evolution of regulatory frameworks is expected to enable aggregators to participate in the wholesale electricity market as well as the ancillary services market.

Another key driver of the growing popularity of BTM storage is co-location of RE production facilities with energy storage, resulting in more stable electricity production and ensuring enhanced capacity during peak demand periods. Japan leads this effort, having developed over 200 MW of BTM storage capacity. The key reason for this growth is expiration of the solar feed-in scheme in 2019, prompting owners of solar PV systems to purchase battery systems to increase self-consumption and mitigate losses. California, driven by the need for grid resilience in the wake of widespread wildfires, has installed over 10,000 BTM storage systems. The European Clean Energy Package (CEP) has defined storage as an entity separate from generation, transmission, or load, preventing it from being double-taxed when charging and discharging. Australia is also a key market for BTM storage as virtual power plants are quickly gaining popularity to aggregate distributed assets.

Applications of behind-the-meter storage

Resilience
Uninterrupted power supply and diesel displacement

Demand aggregation
Load shifting and local flexibility

Increasing the value of renewable energy
Residential (PV + storage)
C&I (PV + storage)

Electric vehicles
Increasing the capacity of BEVs and PHEVs

Source: CSE

> IESA's analysis projects a base case scenario of 226 GWh of storage in India in the next seven years, of which BTM would comprise 75 per cent. Commercial users will drive demand for EVs in the next few years (fleet operations) with personal transportation picking up after 2025
>
> **Rahul Walawalkar**

> Agriculture sector will be the biggest opportunity for electric vehicles, exceeding that of the passenger cars segment
>
> **Krishan Kumar Tiwari**

> Electric vehicle transition should be technology agnostic and not favour any particular technology
>
> **Anant Jain**

1 Available at https://www.iea.org/reports/energy-storage, as accessed on 14 January 2021

But for storage to really revolutionize the way we produce, distribute and use energy, rapid innovations are required, beginning with material science advancements in battery technology and changes in policies and regulations vis- -vis energy systems. Raw materials used in batteries can only be mined in a few places on Earth. Transportation of these materials to different parts of the world to produce lithium-ion batteries results in massive carbon footprints. Adoption of recycled materials can reduce CO_2 emissions from the production cycle by up to 90 per cent. Moreover, proper disposal of batteries is also a safeguard against environmental and health hazards associated with lithium-ion battery waste.
The two most rational solutions to ensure reuse and recycling of lithium-ion batteries are:

Short-term solution, i.e., second life use: Lithium-ion batteries used in EVs have a shelf life of less than ten years. After a five–eight year usage period, the power generated by the batteries is not enough to power the EV. Such batteries can be used in secondary applications, as they retain 70–89 per cent of their initial capacity and can function for several more years.

Potential second life uses include:

» Electric power management for residential and commercial spaces
» Power grid stabilization (firming up peak power)
» Firming up RE systems by providing storage

Challenges in utilizing batteries for second life:

» Lack of policies and protocols for reuse of batteries for energy storage. At present, consumers have no assurance that second life batteries will provide a standard and reliable service. These batteries are not supplied by certified manufacturers or distributors.
» Absence of any methodology to assure EV manufacturers that end-of-life batteries will be repurposed for a reliable reuse and waste products from the second life will be handled and disposed of in an environmentally sound manner.

Long-term solution, i.e., closed loop recycling: Second life battery usage is not in itself sound disposal, as the battery still contains heavy metals. It then needs to go through closed loop recycling to extract useful elements. This can be done through:
» Direct recycling: This is a mechanical process and includes crushing and physical separation of the components and recovery of the black mass.
» Pyro-metallurgical (with heat and flame) recycling: Requires processing of spent lithium-ion cells at high temperature without any mechanical pre-treatment.
» Hydro-metallurgical (with liquids and chemicals) recycling: Involves mechanical pre-treatment and metal recovery from the black mass by means of leaching, precipitation, solvent extraction, ion-exchange resins and bio-leaching.

The panellists deliberated on the drivers and use cases of the fast evolving BTM battery storage industry. The caveats that need to be considered to ensure a sustainable framework for managing this upcoming boom were also underlined and discussed. The fast pace of development of BTM energy storage sector is due to drastic cost reductions in batteries driven by mutually reinforcing mechanisms that interconnect distributed RE, electric vehicles, advances in digital technologies and smart grids. Although the fast pace of developments in the BTM storage sector create exciting new opportunities to push the frontiers of technologies and integrate them better into the society, the very real environmental externalities need to be worked into calculations and future scenarios for them not to act as an impediment to the speed of innovation. The management framework needed in this regard includes areas of R&D, deployment and disposal of BTM battery storage.

It was noted that despite the existence of a plethora of regulations in India, it is only recently, through the Battery Waste Management Rules, 2020 (Draft) that the government has indicated its intent to consider disposal of Lithium-ion batteries a policy problem. Although this is a good start, more work needs to be done as the Rules are yet to be notified. They need to better reflect the current state of energy storage development by being more specific and including new battery technologies that will be utilized by EVs and BTM applications. This is also a great opportunity for India to bring out comprehensive and updated regulations on Extended Producer Responsibility (EPR) to ensure the duties and responsibilities of producers for 'collection and channelization of their products at post-consumer stage of their life cycle' is unequivocally spelled out.[2]

2 Available at https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/SiteAssets/Pages/Events/2019/Policy-awareness-workshop-on-E-waste/27-11-, 2019%20Implementation%20experience%20of%20current%20%20Indian%20Legislation.pdf, as accessed on 14 January 2021

On the manufacturing side, global capacity is likely to increase by 1,500–2,000 GWh by 2022, of which India will only contribute a modest 50 GWh.[3] However, this is still a significant opportunity as it can create substantial domestic value addition in terms of manufacturing capabilities and presents India with an opportunity to develop a model and robust recycling and disposal system. These endeavours sit well with the Make in India and Swachh Bharat Mission and will ensure long-term energy-related sustainability.

India is also host to some unique sectors for deployment of BTM and EVs, as was pointed out by an electric tractor manufacturer. Contrary to popular perception, the agriculture sector could be the biggest opportunity for EVs in India, outperforming the passenger cars segment. The importance of the agriculture sector of the country cannot be understated in any discussion and it is likely to make an impact on the clean energy transition as well. Electric tractors are becoming popular with farmers due to protection from fumes—preventing diesel fume deposition on crops—thus enhancing the overall quality of farmers' lives and food products. The farming sector also presents a logistical advantage in that the charging of electric tractors is easier as the distances covered are substantially smaller, ensuring that the vehicle is always close to a charging station.

In a similar vein, India has another unique EV sector in the form of e-bicycles for mass transport that shows a lot of market potential in terms of adoption for commuting purposes for a large section of the population.

The race for developing storage technologies presents several opportunities that encompass moving to smart and clean energy systems, improving digital technologies, sustainable waste management and manufacturing. All of these issues have long-term ramifications and need political will and level-headedness to move fast and in the right direction.

3 Available at https://economictimes.indiatimes.com/news/economy/policy/niti-aayog-seeks-cabinet-nod-for-battery-push/articleshow/73569360.cms?from=mdr, as accessed on 14 January 2021

The way forward

CSE believes that given the encouraging projections of growth of BTM technologies, that are ushering in a consumer-centric clean energy transition, we need to lay down robust and sustainable principles for Extended Producer Responsibility (EPR) in the sector. This starts with development of a legal framework that is explicitly directed towards externalities in general and handling of battery waste in particular. Our experience with the solar and wind energy sectors has been that we have tremendously benefitted in terms of reduction in greenhouse gas emissions and energy security. But questions regarding the disposal of waste from solar and wind power plants, and the handling of decommissioning of these plants, remain unanswered or unsatisfactorily answered. We must not repeat the same mistakes with new generation batteries that are about to flood the market.

CSE also believes that issues of material security of rare earth elements required to produce these batteries need careful consideration. It would be self-defeating if in an endeavour of freeing ourselves from the hegemony of petro-economies, we end up becoming dependent on an entirely new group of oligarchs controlling rare earth materials required for the clean energy transition.