***ENERGY STORAGE FOR RENEWABLES DEPLOYMENT IN INDIA: POTENTIAL, ECONOMICS AND TECHNOLOGY OPTIONS***

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## Overview

The Indian government is undertaking ambitious plans to ensure energy access and energy security for its 1.2 billion people. Several studies have estimated that the present installed power generation capacity of about 240 GW will have to increase to 600–800 GW by 2030 to meet this growing energy demand. It will be difficult to meet this challenge only with the energy sources such as coal, gas and even hydro. The renewable sources such as wind and solar are expected to play a major role in the future Indian energy mix. In fact, the Indian Planning Commission`s recently published report on Low Carbon Inclusive Growth estimates targets of over 100 GW each for wind and solar power respectively by 2030. There is a need to re-engineer the Indian power infrastructure to absorb such high levels of renewable generation without causing grid instability. It is, therefore, important to estimate the prospects for energy storage as enabling technologies for the Indian renewable energy sector. At the same time, it is essential to analyse the economics of using storage technologies in India. In India, energy storage can play a crucial role in four main areas: National power grid, rural microgrids, roof-top photovoltaic (RTPV) and telecom sector. For a future Indian power grid (Horizon: 2030) with significant renewable penetration, a total storage requirement of 350 GWh can be estimated to alleviate the supply-demand mismatch of power. For a scenario where solar PV based microgrids are set up to augment power supply conditions in Indian villages, a total storage requirement of 3 GWh and more than 40 GWh can be estimated respectively for un-electrified and electrified villages. RTPVs will play a major role in the Indian renewable energy sector, and a storage demand of 20 GWh can be estimated for urban RTPVs in India. The coming few years will see a growing demand for energy storage technologies in India. A part of this can be met by existing storage technologies such as Pumped Hydro-electric Storage systems (4.8 GW installed capacity at present). However, research is required to develop futuristic storage technologies, in particular advanced battery systems for meeting the overall requirements. There is a need to promote research and deployment of these technologies with an appropriate policy framework.

## Methods

This work

1. estimates potential for energy storage in supporting solar PV based mini-grids in off-grid and grid-connected villages, RTPV installations in urban households, and PV powered telecom towers in India,
2. assesses the economic value of energy storage technologies and compares with diesel back-up which is the conventional practice during load-shedding in rural India, urban households and telecom towers,
3. models high renewable energy scenario, their related impact on the future Indian power grid (Horizon: 2030) and how energy storage can play a role to close the supply-demand mismatch of power, and
4. discusses strategic aspects related to storage technologies in an Indian context and describes a roadmap for policy-makers to facilitate storage deployment.

## Results

This work brings out several salient features related to economics and technology options that are important when enabling the deployment of renewable power in India by using energy storage technologies. A few results are described below-

1. Sodium Sulphur (Na/S) battery and Vanadium Redox Battery (VRB) technologies can make rural PV based mini-grids in India competitive with electricity generation from diesel. For Na/S battery supported PV based mini-grid, the study calculates an LCOE of Rs. 27/kWh for un-electrified model village and Rs. 20/kWh for the electrified case. These costs drop down to Rs. 17/kWh and Rs. 13/kWh respectively when the 30% MNRE (Ministry of New and Renewable Energy, Govt of India) subsidy on capital costs is taken into account. For VRB supported PV based mini-grid, the study calculates an LCOE of Rs. 35/kWh for un-electrified model village and Rs. 27/kWh for the electrified case. These costs drop down to Rs. 25/kWh and Rs. 20/kWh respectively when the 30% MNRE subsidy on capital costs is taken into account.

2. Storage can assist in diesel abatement in most urban Indian households where diesel generators are used as backup power source during load shedding. An LCOE range of Rs. 6.15-8.24/kWh and a payback time of 7 years were estimated for an Indian urban household having RTPV system with battery backup.

## Conclusions

1. Taking into account the techno-economic feasibility of currently deployable battery technologies, the best options to meet storage requirement for rural mini-grids are Sodium Sulphur and Vanadium Redox Flow battery systems.
2. Considering techno-economic and customer satisfaction related aspects such as size constraints and safety, lithium ion and advanced lead acid batteries are the ideal storage solutions for urban RTPV sector in India.
3. Lead acid, Lithium-ion and Vanadium Redox Flow batteries can play a major role in abating diesel requirements for power backup in Indian telecom towers. Coupled with solar PV, these battery technologies can help curb huge amount of GHG emissions from the Indian telecom sector

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