ANALYSIS OF LARGE-SCALE ENERGY STORAGE OPTIONS FOR THE INTERCONNECTED ELECTRICITY SYSTEM IN THE INDIAN SUBCONTINENT

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Introduction

While the rest of the world is welcoming a new decade, the Indian subcontinent region is ushering in a new era of renewable energy. Increased interest in electricity generation from Variable Renewable Energy (VRE) sources in the Indian Subcontinent region has led to both positive and complex situations. The electricity sectors of several countries in the region have now long term and sustainable plans to improve their respective shares of renewable energy sources. With increasing awareness to the impacts of climate change, and agreements to the United Nations Framework Convention on Climate Change (UNFCCC) [1] and the Sustainable Development Goals (SDG 2030) [2], the world's largest development in renewable energy is being seen in the Indian electricity sector [3]. Large shares of solar PV, and Onshore wind capacities are being implemented as of now, and several more adding to a total of 175 GW are proposed in the coming decade. Such a large penetration of VRE sources needs to be supported by a significantly large energy storage capacities, for a sustainable and efficient working of the said electricity system. Unfortunately, large scale energy storage options in the Indian subcontinent as of now is very limited [4], with pumped hydro capacities amounting up to 5 GW and few installations of battery storage capacity installations. Furthermore, the accelerated implementation of India's electromobility goals could also create a complex situation without large energy storage installations [5][6]. The Table 1. illustrates the available and proposed/ planned energy storage capacity installations in the Indian electricity sector in the year 2019. Exploration of the several available energy storage options and a strategy for a barrier-free integration of such capacities in the interconnected subcontinental electricity sector is a much-needed necessity. Additionally, techno-economic simulations of the designed strategies provide a better understanding of the situation now, and also of the several unforeseen impacts on the electricity sector due to the implementation of the said strategies.

Status (values in MW)	**Pumped hydro storage**	**Battery storage**	**Total**
Existing (2019)	5757	125	5882
Proposed (until 2040)	8900	5000	13900
Total	14657	5125	**19782**

Table1. Existing and proposed energy storage installations in the Indian electricity sector, Source: MNRE [3], IESA [5]

Methodology implemented

Several challenges exist for choosing a specific technology set for large scale energy storage in the region. Thus, with regards to availability and implementation, pumped storage and Li-ion battery storage systems easily become the best energy storage options in the subcontinent region. Subsequently, the locations of specific storage installations in the overall model regions are also to be determined both with the availability of identified potentials (pumped hydro), and the several existing published information on energy storage (battery installations) in the region. In the next step, two scenarios for the integration of around 20 GW of energy storage capacities are designed in the scope of this study, with focus on the two storage technologies. A unique techno-economic simulation model ATLANTIS_India [7], developed at the Institute of Electricity Economics and Energy Innovation, Graz University of Technology has been then used to simulate the two defined scenarios as close to reality as possible.

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The Figure 1. shows a visualization of the technical physical layer of ATLANTIS_India, and the various pumped hydro installations in the subcontinent. Finally, the wide spectrum of simulation results ranging from electricity prices, capital stock evaluations, to load flows in the transmission network are analysed, and the two scenarios are evaluated in detail. Several conclusions are then to be derived from the evaluations of the simulation results.

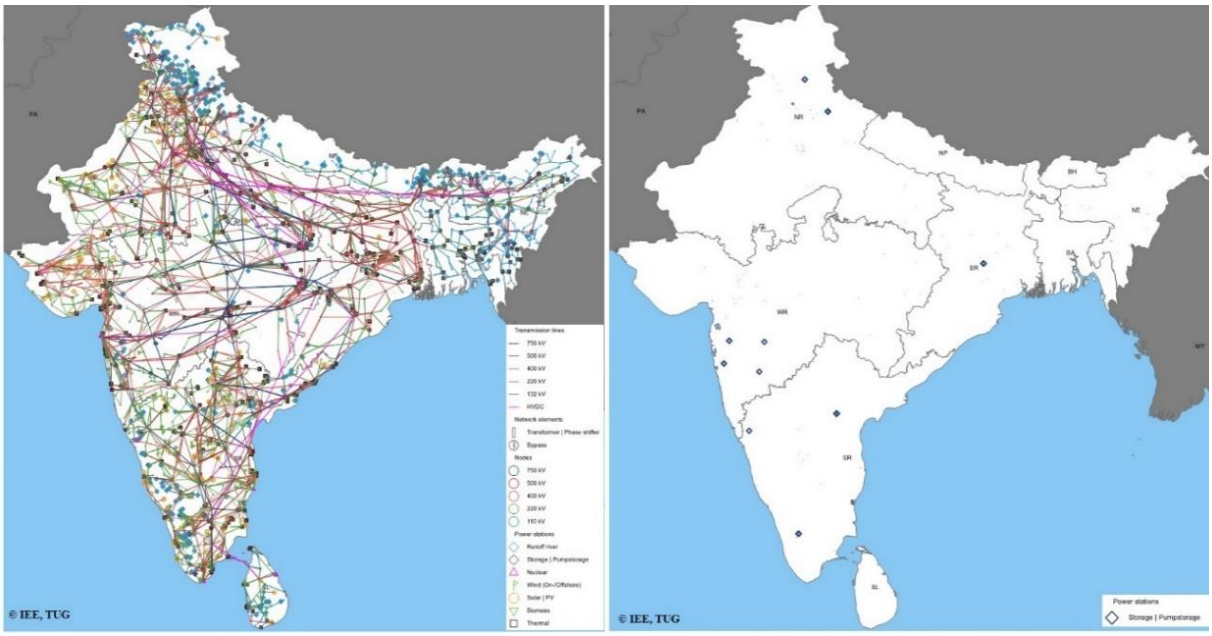

Figure1. The technical physical layer of the simulation model ATLANTIS_India (left) and the various pumped hydro installations in the subcontinent region (right)

Conclusions

With the role of energy storage in the regional interconnected system not just limited to ensuring energy security, but extending to the seamless and efficient performance of the electricity system, integration of energy storage capacities has to be given utmost priority. Along with the planning of VRE capacities and grid extensions, energy storage capacities have to be timely and strategically planned. The simulated technical results provide a keen understanding of the interplay between the storage capacities and the system, and system specific conclusions on the discussed strategies can be obtained. The economic simulation results suggest largely on the improvement of pumped storage capacities, as significant priorities for sustainability are much more focused on the building up of the capital stock of regional electricity sector.

References

[1] U.N. Framework Convention on Climate Change (UNFCCC, COP 21) proceedings (2015) https://wri-india.org/events/unfccc-cop21
[2] NITI Aayog, GoI, (2017) 'On the implementation of Sustainable Development Goals', Voluntary National Report, India, July 2017
[3] Ministry of New and Renewable Energy, Government of India, https://mnre.gov.in/
[4] Rohit AK, Devi KP, Rangnekar S (2017) 'An overview of energy storage and its importance in Indian renewable energy sector' The Journal of Energy Storage 13:10-23 DOI:10.1016/j.est.2017.06.005
[5] India Smart Grid Forum, India Energy Storage Alliance, (2019) 'Energy Storage Roadmap for India 2019–2032'
[6] http://isolaralliance.org/docs/ISGF%20%20Final%20Report%20on%20Energy%20Storage%20System%20(ESS)%20Roadmap%20for%20India%20(2019-2032).pdf
[7] India Energy Storage Alliance, https://www.indiaesa.info/resources/storage-101
[8] Bhat, K.S., Bachhiesl, U., Feichtinger, G. et al. Elektrotech. Inftech. (2019) 136: 361. https://doi.org/10.1007/s00502-019-00773-w