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Large scale electrical energy storage systems in India- current status and future prospects

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ABSTRACT

Backed by various promotional schemes and policies of the government, share of renewable energy sources (RES) is increasing in a faster way in India. Country has to promote the exploitation of renewable resources for a sustainable power system and economy. Increased penetration of intermittent RES affects the grid stability. Electrical Energy Storage (EES) systems are promising solution for grid stability issues. Different types of EES systems are developed all over the world and a number of storage technologies are under experimentation. This paper is mainly focusing on the status of the development and future prospects of large scale electrical energy storage systems in India. Significance of EES systems in modern power systems, overview of the existing large-scale EES systems, Comparison of large-scale EES systems and advantages and disadvantages of various storage technologies etc. are discussed in this paper. List of existing and developing large scale EES projects in India is introduced. Challenges in EES development in India and its significance in future are also studied.

1. Introduction

All over the world Renewable Energy Systems (RES) are gaining more popularity in recent years. One of the challenges faced in the increased penetration of RES is the grid stability issues [1]. Diesel or hydel plants usually serve as peak hour energy providers and there are limitations in using these plants with rapidly growing RES penetrations. There are economic and technological limitations in utilizing diesel and hydel plants for generation shifting. Development of EES is important for effective utilization of RES. Electrical Energy Storage (EES) can enhance the grid stability in multi dimensions [1–3]. Developed countries like US, Japan and Germany have developed some large-scale EES systems and in developing countries like China construction works are progressing [4–6].

India is mainly depending on the fossil fuels for its electrical energy needs. Coal based power plants serve 61% of total demand [7]. In order to reduce economic burden, pollution, oil imports and to promote RES utilization, Government of India (GoI) has launched several programmes and policies. RES capacity of the country increased from 6 MW in 1985 to 57260 MW in 2017 [8,9]. Total installed capacity of the country is 334399.83 MW as on 31st January 2018, and it is comprised of Coal (193821.50 MW), Gas (25150.38), Diesel (837.63 MW), Nuclear (6780.00 MW), Hydro (44963.42 MW), RES (62846.90 MW) [10]. Total installed capacity and share of various sources are depicted in Fig. 1. Share of electricity consumption by utilities in India as on 31.03.2017 is shown in Fig. 2 [11].

Indian Electricity act 2003, National Electricity Policy-2005and National Solar Mission of GoI acted as the catalyst for RES development in India. This study is considering the significance of EES in the future Indian power industry. Various aspects like role of EES in power system and energy market, large-scale storage technologies, comparison of large-scale storage technologies, status of EES in India, demand for EES in future and challenges of EES development in India are covered in this study.

2. Significance of storage systems in power systems

Without a capacity addition, EES contributes greatly to power system in the following contexts.

2.1. Balancing generation and demand fluctuations

In a power system, both the electrical demand and generation are fluctuating in nature. Demand fluctuation depends on the end user

Abbreviations: BES, battery energy storage; BMU, battery management unit; CAES, compressed air energy storage; CEA, Central Electricity Authority of India; CERC, Central Electricity Regulatory Committee; DoD, depth of discharge; EES, electrical energy storage; FES, flywheel energy storage; GoI, Government of India; IESS, India energy security scenarios; MNRE, Ministry of New and Renewable Energy; NEMM, National Electric Mobility Mission; PSH, pumped storage hydro; PV, photo voltaic; RES, renewable energy sources; RVE, rural village electrification; TES, thermal energy storage; V2G, vehicle to grid

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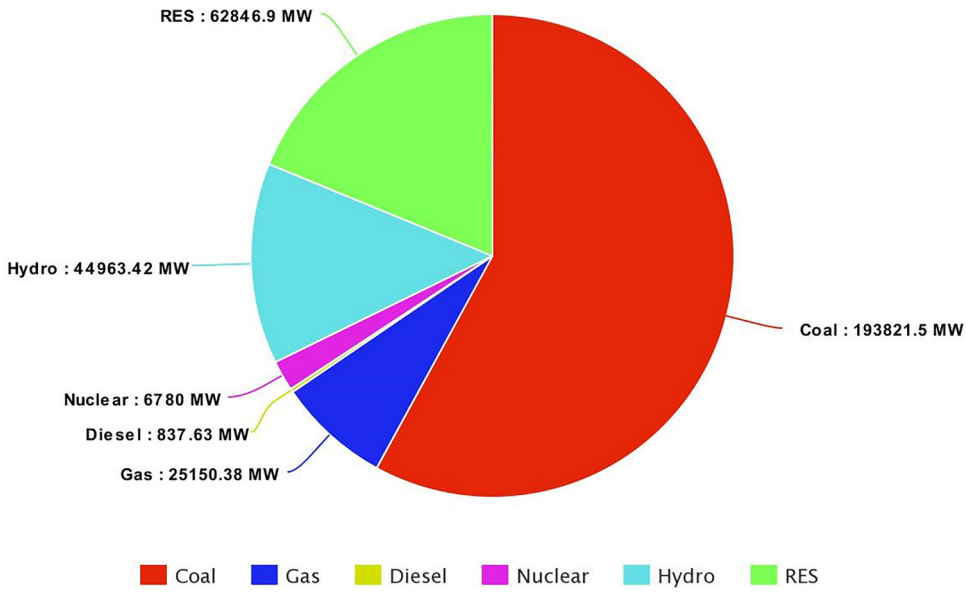

Fig. 1. Share of various sources in energy mix of India.

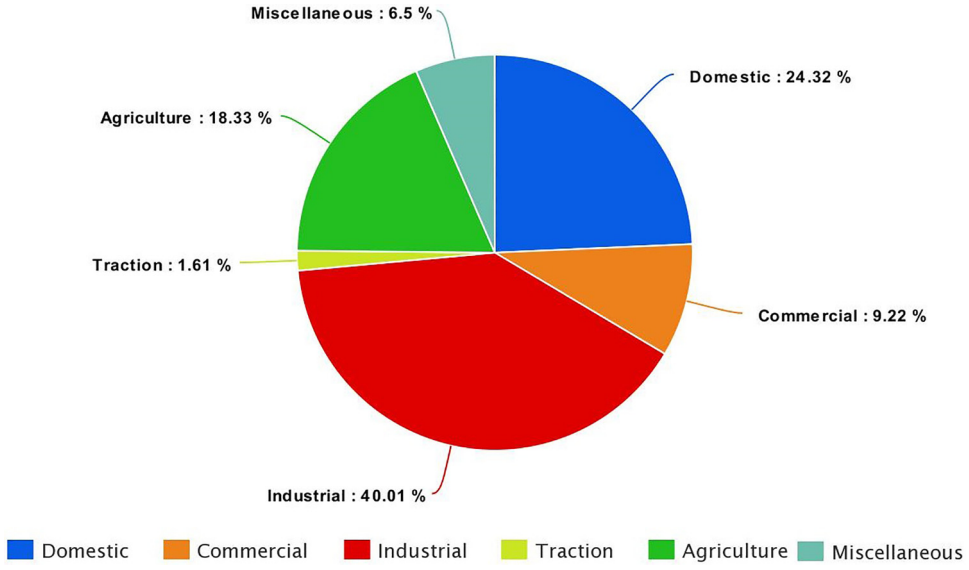

Fig. 2. Share of electricity consumption by utilities.

consumption characteristics. Renewable energy penetration is one of the primary sources of generation fluctuation because of their intermittent nature. Frequent fluctuation of demand and generation affects the stability of the grid and makes the system control complicated. During the peak electrical demand hours generally hydel or gas plants are operated due to their fast synchronizing capability. But availability of hydel plants is limited due to many reasons and operating gas plants for peak demand hour requirements will result in practical difficulties and added cost. Thermal plants exhibits lower efficiency for low load factors and results in uneconomic operation. Therefore there is a minimum demand requirement to maintain the economic generation. EES can act as a load without wasting energy during excess generation hours and can act as a generator during peak demand hours so that generation and load balance can be achieved [12].

2.2. Balancing intermediate renewable energy penetration

Usage of RESs is increasing expeditiously. Intermittent nature of RES leads to intermittent generation and affects grid stability. EES can store the energy whenever it is available and discharge it to make the generation continuous. EES can act as buffer between RES and grid so that the grid is less affected by intermittency of generation [12].

2.3. Grid utilization

EES can support the power system during peak hours with stored energy and reduce transmission congestion due to overloading. This will increase the life of transmission infrastructure and reduce transmission capacity investments [12,13].

2.4. Market operations

In a decentralized system the generating companies (Gencos) will be penalized for deviating from scheduled generation. Gencos are forced to purchase high cost energy from gas plants to avoid this penalty imposed by regulatory authority. Higher RES penetration will increase grid frequency and higher demand will decrease grid frequency. Gencos must maintain grid frequency in specified band to avoid penalties from