Off-grid energy storage nepal

a Global share of renewable energy 2020, and b Globally generated annual renewable energy over the past years (Data Source: (IRENA 2021b))

These initiatives and policies indicate that GoN and relevant stakeholders have realized the need to modernize and upgrade the power system. Still, progress is slow due to their complicated physical and socio-economic aspects. Therefore, the future trend is restructuring the Nepalese energy sector through smart grid technology to provide a high degree of energy security and reliability, which requires in-depth discussion and analysis concerning its massive potential and benefits and associated challenges.

Nepal"s gradually improving economy needs safe access to modern energy technologies to exploit/utilize its vast RESs for long-term growth and prosperity. Therefore, transformation to smart grid technology is required to make better use of current infrastructure and include new technologies in the future. The main driving forces that necessitate Nepal"s smart grid transition are addressed in the following sections.

Key causes and consequences of Nepal insufficient and unreliable power supply (Data

Electricity demand at different scenarios with predicted ones (Data Source: (WECS 2017))

Required installed capacity under different scenarios with predicted ones (Data Source:(WECS 2017))

The transportation sector is among the rapidly expanding sector of Nepal, which is responsible for consuming a significant portion of fossil fuel and GHGs emissions. The percentage of fuel consumed by the transportation sector in total fuel consumption has jumped from 49% in 2007 to 67% in 2017 (Zhou et al. 2020). With a rise in consumption, the emission of GHGs like CO2 has also elevated inexorably. In 2017, 45.4% of overall CO2 emission was released by the transportation sector in Nepal (Zhou et al. 2020). Such emission has contributed to air pollution and global warming, which have a deteriorating effect on human health and the environmental ecosystem (Shrestha et al. 2017).

Therefore, to restrict the rising GHGs discharges from carbon-intensive technologies, it is suggested that the nation should take essential activities to shift to alternative low carbon technology. Electrifying the transport sector would be a sustainable solution to restrict GHG emissions (Kainuma et al. 2017). But the current scenario is quite the opposite, where imported oil products fully fulfill energy demand in the transport sector. Electricity shared only 0.06% of the final energy consumption of the transport sector, whereas oil products shared 99.94% in 2017 (Zhou et al. 2020).

Power transmission network map of Nepal, 2020 (Data Source: (The World Bank 2013; RPGCL 2020))

For transforming into a smart grid system, these issues need to be rectified by introducing Flexible AC Transmission System (FACTS) and Resilient AC Distribution System (RACDS) technology (Zhang et al. 2012). Some of the critical roles of FACTS and RACDS for transition into the smart grid in Nepal are illustrated in Fig. 6.

The Institute of Electrical and Electronics Engineers (IEEE) has defined FACTS as "a power electronics-based system and other static equipment that provide control of one or more AC transmission system parameters to enhance control- liability and increase power transfer capability" (Edris et al. 1997). In the existing grid of Nepal, it is impossible to control different electrical parameters like impedance, phase angle, and magnitude of voltage in real time, which constrain the grid flexibility. But with FACTS devices and controllers, these parameters can be altered and composed in real time, offering a new level of opportunity for managing the network.

Schematic illustration of the transmission network in a smart grid (modified after (Peng and Wang 2019))