ABSTRACT

Today when global environmental change is posing a growing challenge to the world's economy and creating doubts about the survival of humanity, coal thermal power plants are under tremendous pressure to satisfy rigorous environmental regulations into attaining worldwide set millennial objectives for alleviating the effect of emission gases on the atmosphere. Due to the abundance of coal, it is unlikely to see the use of coal completely missing from the global energy mix within the next hundred years to come. Energy is a critical factor for the economic and social development of a nation. India being a developing nation will require a tremendous amount of energy for its economic and social development in the near future. The limited availability of conventional sources of energy and the problems of environmental degradation associated with them compels the need for a new sustainable energy option that uses renewable energy sources. Among renewable sources of energy, solar energy is the most abundantly available and feasible option for electricity generation. Solar thermal only plants have very high initial investment and, due to the intermittent nature of solar energy, can be used only during the daytime. This limitation of solar thermal only plants leads to a novel concept of integration of coal-based power plants with solar thermal energy. In India, the energy consumed for different applications, either domestic or industrial, primarily originates from coal. Therefore, the hybridization of solar energy with existing coal-fired power plants (CFPP) has profound and realistic implications.

Case study-1 investigates the integration of sub-critical CFPP with solar energy using PTC solar field for feedwater preheating, replacing extraction steam in fuel-saving and power-boosting mode. The 4-E analysis (energetic, exergetic, economical, and environmental) of a 330 MWe sub-critical coal-fired thermal power plant integrated with solar thermal energy is presented. The integration of solar energy into the existing 330 MWe sub-critical coal-fired thermal power plant is done using three replacement options. The energetic and exergetic analysis results show that the highest energy efficiency of 38.04% and the highest exergy

efficiency of 36.22% are attained for Option-3. The environmental analysis performed using the fuel-saving approach shows that the maximum reduction in coal consumption (37104 tons of coal) and CO_2 emissions (73213 tons of CO_2) also corresponds to Option-3. The economic analysis showed that for all three replacement options, the Levelized cost of electricity (Cents/kWh) is obtained as 4.52, 4.47, 4.63 respectively, and simple payback period (years) is found as 3.4, 3.3, 3.6 respectively.

Case study-2 examines the integration of supercritical CFPP with solar energy using PTC solar field for feedwater preheating, replacing extraction steam in fuel-saving and power-boosting mode. This case study investigates the hybridization of an existing supercritical 660 MWe coal-based power plant with concentrated solar thermal energy on technical, environmental, and economic criteria using three different scenarios. The results show that the cycle efficiency increases from base case cycle efficiency 41.74% to 44.36%, 47.41%, 48.72%, respectively, in all the three replacement options. The economic analysis showed that for all three replacement options, the Levelized cost of electricity (Cents/kWh) is obtained as 4.56, 4.69, 4.82 respectively, and simple payback period (years) is found as 3.3, 3.7, 3.9 respectively. The environmental factors such as annual reductions in coal consumption and CO_2 emissions, and solar contribution have also been evaluated.

Further to boost the deployment of solar thermal energy technologies in India, it is enlightened that the government needs to support industry partners through different measures; feed-in tariffs (FIT) reflecting the value of CSP, risk cover for innovative designs, project demonstrations, and financial incentives. This research work discusses the current policies of various states focusing on solar energy. Also, it presents a state-wise analysis of renewable purchase obligations (RPOs) and renewable energy certificates (RECs). The recommendations are provided to promote the integration of solar energy with CFPP to augment the power output of the existing plant through appropriate policy enablers.