Managing production–demand mismatch in thermal power plants

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The present policy of the Government asking regional electricity grids to absorb all the power generated by renewable power installations, and the thermal power stations to run at lower capacities than their installed values would not only force many thermal power plants to run at power levels much lower than their design values, but also constantly ramp up and down their outputs every day causing more wear and tear of the system. We suggest that the problem can be avoided by running the thermal power plants at their installed capacities, and use the surplus electricity to produce and store onsite hydrogen and oxygen. The stored hydrogen can be subsequently used not only to supplement coal in their own furnaces, but also for a variety of applications such as production of ammonia for fertilizers, as automobile fuel or for any other industrial applications. The ultrapure oxygen may be marketed for medical and other industrial applications.

Per capita electricity production or consumption availability is widely accepted as a proxy for development, using the well-known quantitative metric yardstick of Human Development Index (HDI) across the world. India's current per capita electricity consumption (of 1181 kWh/yr) is far below that of not only developed countries, but also of many developing countries. It is generally suggested that per capita electricity consumption of about 4000 kWh/yr is adequate to provide a comfortable HDI of about 0.8 (ref. 1).

Coal has always been the mainstay of electrical energy in India. With increasing concern on CO_2 emission and decreasing cost of electricity using renewable energy technologies, India is aggressively increasing the share of solar photovoltaic as well as wind electricity in the national electricity basket. This has not come without a cost. Solar electricity is subjected to strong day/night variations, while the electricity from windmills has strong temporal and seasonal variations. With the lack of large-scale battery technologies for storage of electrical energy, this puts serious pressure on the thermal power stations in grid balancing by ramping their power output up and down every day, operate below their design capacities and incur considerable loss of revenue. For example, the Central Electrical Authority of India, has estimated[2] that on a typical day in 2021 electricity production is expected to be as shown in Figure 1. This is, of course, season-dependent.

One cannot miss the rapid ramping down of electricity generation from thermal power plants to almost 30% over 6 h in the forenoon and then the rapid ramping up of the generation over 7 h in the afternoon to its full capacity. It implies that these plants will be required to operate at a capacity much lower than their design values for over 13 h every day. A recent article by Mahalingam *et al.*[3] points out that the present policy of urging thermal power plants to run at much lower capacities than their installed values to ensure grid stability, and the grids to get all the power generated by the renewables has indeed forced many ultra-modern thermal power plants to essentially run well below their design capabilities or lie idle, incurring huge losses. This is not simply a loss to the station, but a national loss. We also note that India has ambitious plans to increase the national power production in the coming years. New coal power plants with a total capacity of 62 GW are already under construction in the country. India has also set itself a target of 175 GW renewable energy capacity by 2022, including 100 GW of solar and 60 GW of wind power capacity. The problem of surplus capacity will be exacerbated in the times to come, as the additional renewable energy power plants come up. This will require even more thermal plants to perform at much lower levels than their full capacity to accommodate the production from renewable energy sources. This, we feel, is a gross wastage of precious national resources.

Pumped-up hydroelectric storage systems can be effectively used to store the excess electricity by pumping water into

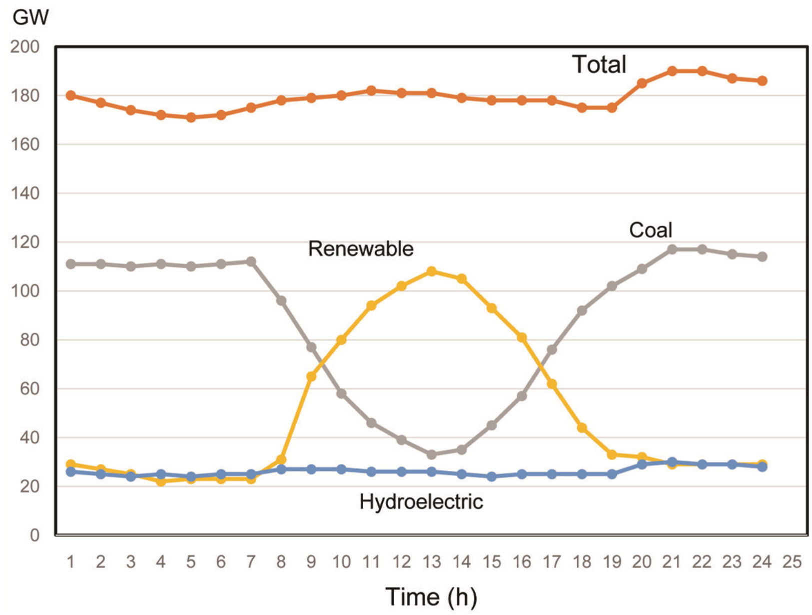

Figure 1. Contributions from main fuel sources in meeting electricity demand – 2021. (Data are taken from ref. (1). Minor sources are not shown.)

a reservoir at a height and then releasing it back to a reservoir at a much lower height to generate electricity when the demand is high. However, these require special sites at suitable elevation with adequate availability of water. Such sites are mostly found in hilly and ecologically sensitive terrains. One could also use existing dams for this by having reversible turbines. However, as shown in Figure 1, the available capacity in the country is quite small.

We suggest that the problem can be avoided by running the thermal power plants at their installed capacities, and using the surplus electricity to produce and store hydrogen and oxygen on site. Electrolysis of water into hydrogen and oxygen is known for more than two centuries. Presently, efficiencies of 80% are common which may further increase to 85–90% in the near future. Modern storage technologies of the two gases are mature. Large-scale transport of hydrogen, however, poses special challenges compared to transport of liquid fuels like petrol and diesel, and gas fuels like natural gas, retarding the growth of a hydrogen economy requiring further development.

The stored hydrogen can be used partly to increase combustion efficiency in the thermal power plant itself and partly for other industrial applications. For example, it is known from a study of combustion of pulverized coal that an optimum H_2 flow rate (5% of heating value of coal) enhances the combustibility of coal[4]. This will not only reduce the amount of coal needed by the plant per unit of electricity produced, but also reduce the emission of carbon dioxide as well as other pollutants in the stack. A detailed study of this would be valuable.

It is known that compressed natural gas (CNG) enriched with hydrogen (H-CNG) results in much lower pollution than pure CNG. On a directive from the Supreme Court of India[5], a fleet of about 50 buses using H-CNG enriched with up to 18% hydrogen are expected to start plying in Delhi on an experimental basis by November 2020. NITI Aayog, the nodal think-tank for making policies in India, has already recommended that H-CNG be notified as an automotive fuel[6].

Hydrogen can also be used to produce ammonia for fertilizers. Oxygen can be used for diverse industrial and medical applications. It is worth emphasizing that the hydrogen (and the oxygen) produced from electrolysis is 99.9% pure, which is valuable. This will also be in line with the National Hydrogen Energy Road Map[7].

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