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Hydrogen Production at the Forecourt from Off-Peak Electricity and Its Role in Balancing the Grid

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Abstract : The rapid growth of renewable energy sources and their integration into the grid have been motivated by the depletion of fossil fuels and environmental issues. Unfortunately, the grid is unable to cope with the predicted growth of renewable energy which would lead to its instability. To solve this problem, energy storage devices could be used. Electrolytic hydrogen production from an electrolyser is considered a promising option since it is a clean energy source (zero emissions). Choosing flexible operation of an electrolyser (producing hydrogen during the off-peak electricity period and stopping at other times) could bring about many benefits like reducing the cost of hydrogen and helping to balance the electric systems. This paper investigates the price of hydrogen during flexible operation compared with continuous operation, while serving the customer (hydrogen filling station) without interruption. The optimization algorithm is applied to investigate the hydrogen station in both cases (flexible and continuous operation). Three different scenarios are tested to see whether the off-peak electricity price could enhance the reduction of the hydrogen cost. These scenarios are: Standard tariff (1 tier system) during the day (assumed 12 p/kWh) while still satisfying the demand for hydrogen; using off-peak electricity at a lower price (assumed 5 p/kWh) and shutting down the electrolyser at other times; using lower price electricity at off-peak times and high price electricity at other times. This study looks at Derna city, which is located on the coast of the Mediterranean Sea (32° 46′ 0 N, 22° 38′ 0 E) with a high potential for wind resource. Hourly wind speed data which were collected over 24½ years from 1990 to 2014 were in addition to data on hourly radiation and hourly electricity demand collected over a one-year period, together with the petrol station data.

Keywords : hydrogen filling station off-peak electricity, renewable energy, off-peak electricity, electrolytic hydrogen
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