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Sustainable development of road transportation sector using hydrogen energy system



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ABSTRACT

This study reviews the main problems of high air pollution levels at many urban cities and sustainability of the transportation fuels, and addressing their control measures using hydrogen energy system. In the world, majority of the transportation vehicle fleets consume the fuels derived from fossil resources. The development of economy activities indicate the increase in transportation services resulting in increased fuel consumption and high emissions, especially unregulated emission carbon dioxide, which is a greenhouse gas (GHG). Therefore, utilization of hydrogen as fuel in vehicle fleet would improve energy security and reduce the GHG emission. A feasibility of hydrogen energy system, which includes its resources, production technologies, storage, fuel transportation, dispensing and utilization, is analysed for the road transportation sector.

In addition to this, the study highlights the technical issues and its control strategy for addressing the problems of the transportation system using the hydrogen. Moreover, hydrogen is the cleanest fuel, especially when coupled with renewable energy sources. The road transportation sector with hydrogen energy system would give the desirable results including high energy efficiency and zero carbon based emission (CO, CO₂, HC, PM) resulting in strengthening of sustainability of the system. The Governments of many countries have made ambitious policies and provide strong financial support to research organizations including universities and institutions for development of hydrogen energy system. Many companies express strong interest in the commercialization of hydrogen fuelled vehicles either internal combustion engines based, fuel cell based or hybrid technology.

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1. Introduction

Transportation sector caters the world society in terms of easy movement of public and goods in any country. Amongst the various modes of transportation (i.e., road, air and water), the road transportation is one of the most convenient transportation systems, as it provides reliable services like transportation of the goods from upstream of production to downstream of the delivery destination. The increasingly worldwide nature of present society has determined a strong interconnection between human activities, energy utilization and pollution reduction strategies. The increased gross domestic production (GDP) of any country requires more transportation for industrial and economic development; and hence consumption of more fuel leading to the environmental pollution. The pollution problem becomes more serious in the urban areas, especially in metro cities, where millions of people travel by road, air or rail. The road transport is the best choice for people as it provides the facility of moving from their place to other required destination. As the GDP increases, the movement of business people increases parallel. However, these activities lead to leverage of the increase in urban air pollution (Fig. 1). The another major crisis is the depletion of fossil fuels, as oil and natural gas would vanish in 50–70 years. The gap between demand and supply of crude oil increase steeply for recent years and it will continue by many folds until economic activities continue in the world. Therefore, there are twin challenges of urban air pollution in major cities and high transportation cost leading to sustainability issue of road transportation sector [1].

1.1. Worldwide scenario of economic development and pollution

The world economy is growing at very fast rate and needs more energy, most of which is fulfilled by fossil fuels (i.e., coal, oil and natural gas). Increasing fossil fuel utilization in transportation vehicles such as automobiles, ships and aircraft leads to increasing pollution level including CO, HC, NO_x, particulate matters (PM), soot, smoke and CO₂ in urban cities, where the pollution level may go beyond the admissible level. The past trend and projections of vehicle fleets in Asia is shown in Fig. 2 [1], where it can be observed that the vehicle population is increasing exponentially leading to more fuel consumption and increase in emissions level.

As per classification of emissions by the Environment Protection Agency (EPA), USA [2], the CO₂ is not considered in the category of regulated pollutants, but it is a greenhouse gas (GHG) and responsible for global warming and climate change. The transportation sector contribute major portion of GHG emissions, which is primarily from the fossil fuels burned for road, rail, air, and marine transportation. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel [2]. According to the World Bank [3] data, the CO₂ emission is related with the gross domestic production (GDP). The countries with higher GDP are consuming more energy and emitting higher CO₂, as shown in Fig. 3. The threat of global warming has been attributed to fossil fuels [4]. Apart from the CO₂, the methane (CH₄) and nitrous oxide (N₂O), which are associated with tail pipe emissions, are also the GHGs.

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