ABSTRACT

Global environmental problems, such as declining fossil fuel reserves and growing pollution, have increased interest in the development of alternative energy sources. This is particularly important in the transport sector, which is responsible for a large share of greenhouse gas emissions. Reducing these emissions is one of the main elements of the transformation of transport systems. For this reason, hydrogen is considered an alternative fuel that may support the decarbonisation of this sector. The present work focuses on the operation of buses powered by hydrogen fuel cells, due to their growing popularity in the fleets of Polish cities.

The main aim of the study was the environmental assessment of the life cycle of hydrogen, covering both the fuel cycle (Well-to-Wheel) and the vehicle cycle (Cradle-to-Grave). In addition, the key factors determining environmental impact were identified based on the results.

The calculations were carried out using SimaPro software with the Ecoinvent 3.11 database, applying the Environmental Footprint 3.1 method. The functional unit was defined as one passenger-kilometre (1 pkm) with an occupancy rate of 35%, and the reference mileage of the vehicle was set at 800,000 km. The reliability of the results was confirmed by an uncertainty analysis using the Monte Carlo method. In addition, three scenario analyses were performed: a comparison of fuels used in bus transport, a comparison of hydrogen production methods, and a comparison of electricity sources powering the electrolysis process.

The results of the study showed that the use of hydrogen as an alternative fuel in bus transport may support the decarbonisation of this sector. However, the final environmental impact depends on both the method of hydrogen production and the source of the electricity used. Within the vehicle life cycle, these stages had the strongest negative impact on the environment in nearly all impact categories.

This conclusion also confirms that the environmental assessment of fuel cell buses should not be limited to the analysis of the vehicle itself. It should also take into account fuel production and local energy conditions. The results of the dissertation may serve as a basis for formulating environmental criteria in public tenders for urban bus fleets, for ESG reporting, and for guidelines in transport and energy policy.