How can engineers contribute to the development of sustainable transportation solutions that reduce carbon emissions?

“Engineers turn scientific knowledge into solutions for society.” — National Academy of Engineering

The transportation sector accounts for approximately one quarter of global carbon dioxide emissions (International Energy Agency, 2023). As global demand for transportation continues to rise, we rely on engineers to develop new systems to foster a sustainable transportation sector.

One of the most common ways engineers reduce transport emissions is through the **development of electric vehicles**. Electric vehicles rely on a lithium-ion battery, which stores energy through reversible electrochemical reactions. Improvements to energy density, charging speed and battery longevity in electric vehicles enable them to surpass the casual combustion engines. (IEA, 2023). From an efficiency perspective, electric vehicles convert over 75 per cent of electrical energy into motion, compared to roughly 30 per cent for internal combustion engines, demonstrating that electric vehicles are more efficient (U.S. Department of Energy, 2022). In leading companies such as **Tesla, carbon emissions are reduced by designing electric vehicles that run entirely on electricity, meaning they produce no exhaust emissions while driving. According to Tesla’s Impact Report, the company focuses on improving battery efficiency, electric motor performance, and charging infrastructure so that more people can switch to electric transport.** (Tesla Impact Report, 2023). It is proven that life cycle emission of electric vehicles remain lower than conventional vehicles when considering stages such as manufacturing and electricity generation. (Hawkins et al., 2018).

However, the technology used in electric vehicles is not suitable for long-distance transport like in the field of aviation. Batteries become inefficient due to their weight and limited energy storage capacity. To address this challenge, engineers are developing hydrogen fuel cell technology as a complementary solution. Hydrogen fuel cells produce electricity through an electrochemical reaction between hydrogen and oxygen, releasing only water as the product and eliminating carbon dioxide (U.S. Department of Energy, 2022). Hydrogen has a much higher energy content by mass than batteries, so fuel cell vehicles can travel longer distances, making them particularly effective (Nature Energy, 2021). Moreover, **hydrogen is produced using renewable electricity, such as wind or solar power, so its overall carbon footprint is very low. This type of hydrogen produced is known as green hydrogen, in which water is split into hydrogen and oxygen.** (International Energy Agency, 2019). Despite the low carbon footprint, engineers have to take cost and feasibility of the infrastructure to produce green hydrogen (Dunn et al., 2011).

Rolls-Royce engineers have successfully tested a jet engine, AE 2100-A turboprop engine, operating on hydrogen fuel, where compressed air from the atmosphere is used to combust the hydrogen and generate thrust, without producing carbon dioxide (Rolls-Royce plc, 2022). Incoming air is compressed to high pressure and temperature, allowing hydrogen to burn

efficiently using atmospheric oxygen. Hydrogen combustion produces no carbon dioxide (International Energy Agency, 2019). Thus, aircraft engine designs can be adapted to reduce carbon emissions in aviation which is the transport sector which releases a huge amount of greenhouse emission. (UK Department for Transport, 2023).

Furthermore, engineers can redesign vehicle infrastructure to be lightweight. It is shows that reducing vehicle weight and air resistance directly lowers fuel and electricity consumption, cutting emissions across inl transport modes (International Energy Agency, 2023).

Engineers can implement smart traffic management, which can reduce urban transport emissions by up to 20 per cent, (World Economic Forum, 2021) by designing "**route optimisation algorithms", using AI** to ensure vehicles take the most efficient paths leading to lower fuel consumption. (International Transport Forum, 2020).

In conclusion, seeing how engineers transform technology to overcome transport challenges motivates me to pursue a career in engineering to build systems to help resolve global challenges.