Although the investment barrier for hydrogen production infrastructure remains, a useful trait of IC engines is that they are far more tolerant of lower purity fuel than that needed for fuel cells. This tolerance could potentially reduce the requirements of the hydrogen production infrastructure, thus lowering this particular barrier to adoption.

While modifying existing engines may not grab headlines, the use of H_2ICE as a steppingstone technology could enable an efficient path to decarbonised transport.

There is no one perfect solution that fits all situations. The diverse and complex financial, governmental, and societal contexts call for applying all three paths to aid hydrogen adoption. With experience across all these routes and our technology-agnostic approach, the Ricardo rail teams look forward to helping your rail network to find its optimal route to decarbonisation. Please get in touch at ***ricardorail@ricardo.com***

About Ricardo:

Ricardo plc is a world-class environmental, engineering, and strategic consulting company listed on the London Stock Exchange. With over 100 years of engineering excellence, we provide exceptional levels of expertise in delivering leading-edge and innovative cross-sector sustainable products and solutions, helping our global customers increase efficiencies, achieve growth, and create a cleaner and safer future. Our mission is clear – to create a safe and sustainable world.

For more information visit ***www.ricardo.com***

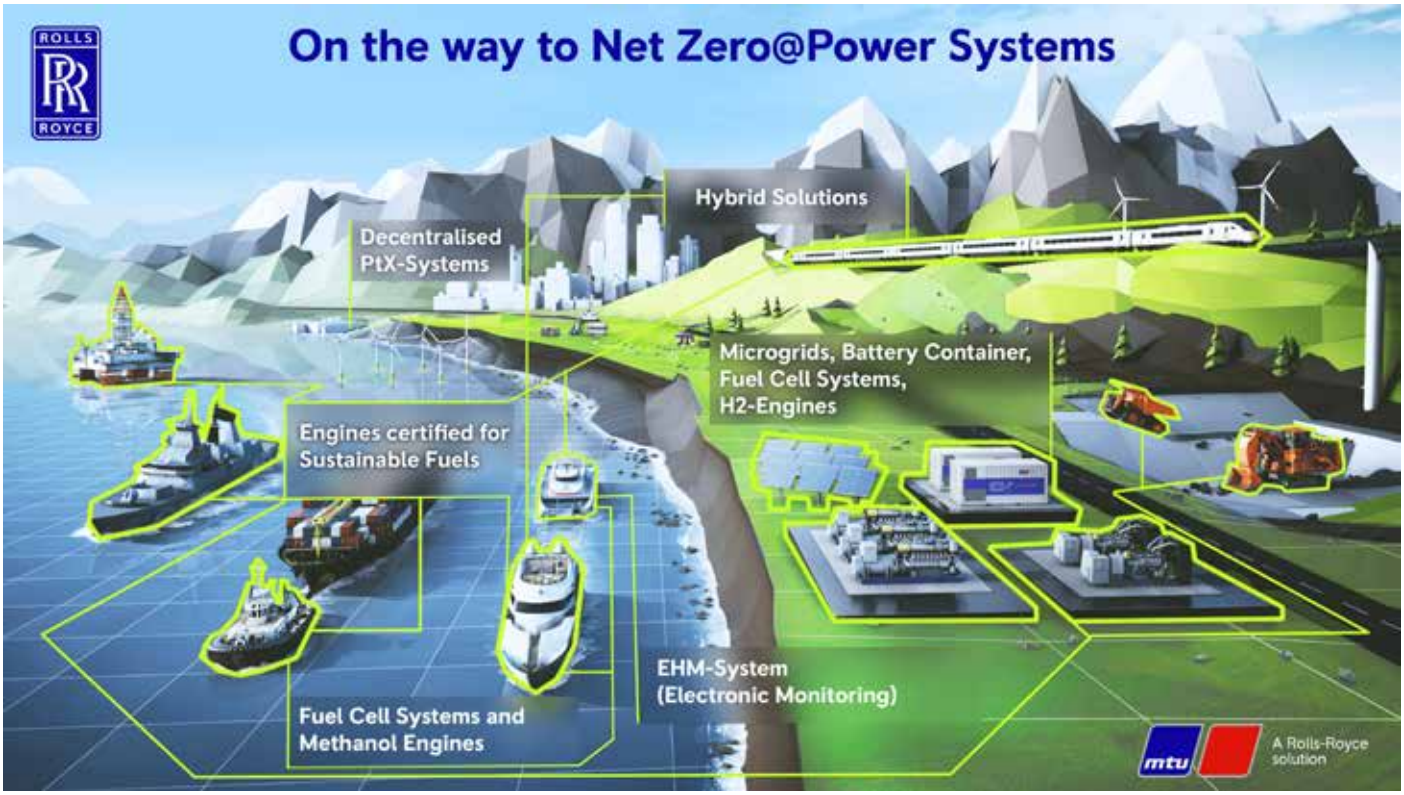
The 30-year-old Diesel Multiple Unit HydroFLEX vehicle has been converted to Hydrogen fuel cell power

Ricardo prepares to test a hydrogen heavy-duty engine

CLEAN BACKUP POWER SOLUTIONS WITH HYDROGEN FUEL CELL SYSTEMS

Rolls-Royce Power Systems announced its climate protection program "Net Zero at Power Systems" in 2021. Thereby the company is clearly committed to the Paris Climate Agreement and its goal of reducing global warming to well below two degrees Celsius with efforts to limit it to 1.5 degrees Celsius compared to the pre-industrial era through climate action. In order to become climate neutral by 2050 at the latest, the Rolls-Royce business unit Power Systems, aims to reduce 35% of greenhouse gases by 2030 with new products compared to 2019 as a first near-term step. Key elements to achieve this include new technologies such as H_2 engines, CO_2-free fuel cell systems and the release of the main mtu engine series for sustainable fuels from 2023, in some cases earlier.

On the way to Net Zero: Rolls-Royce recognises great potential for reducing greenhouse gas emissions in all its products – be it by the means of electrification, hybridisation, system integration or sustainable fuels.

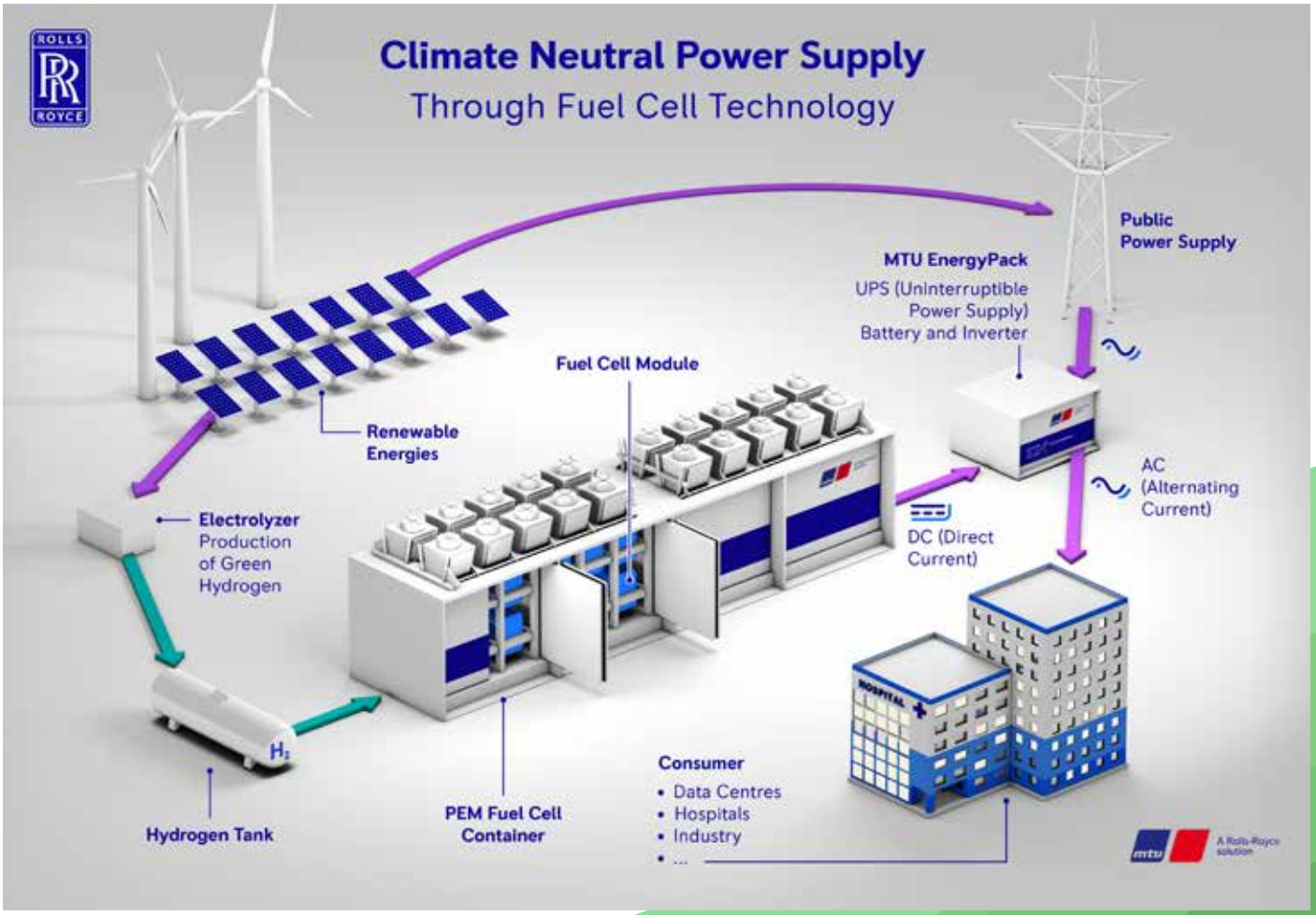


Green Hydrogen can be used as a clean alternative to traditional diesel and gas solutions for reliable backup power supply for data centres, hospitals and industrial applications. Electrical power can be generated from hydrogen through a chemical reaction in a fuel cell, or through combustion in a hydrogen engine, with dynamic response supported through batteries. To ensure that carbon-free power is generated, green hydrogen must be used. This means that the hydrogen is produced through electrolysis, using electricity from renewables such as photovoltaics or wind.

BENEFITS OF GREEN HYDROGEN SOLUTIONS

Decarbonising backup power is both a challenge and an opportunity. All major players in the hyperscale data centre market have committed to net zero emissions targets by 2030 or earlier and this means removing carbon emissions not just from their continuous power demands, but also from their backup power solutions. Hydrogen fuel cell systems provide some additional benefits over traditional diesel backup solutions. One such benefit is that the system, through its high dynamic response and integrated battery storage, enables customers to participate in new revenue streams or to save money on their existing electricity bills.

The hydrogen can either be brought in, or the customer can take advantage of the opportunity to produce the fuel on-site through the installation, for example, of photovoltaic panels on the roof of their buildings and the use of an electrolyser. Through on-site production the customer additionally becomes self-sufficient, completely de-risking fuel supply. The electrolyser can produce hydrogen when renewable sources (e.g., sunshine/wind) are abundant and store this in tanks for a reliable and continuous supply when needed. Excess hydrogen can also be fed into the natural gas grid (dependent on location) supporting the wider energy transition and providing a further revenue stream for the customer. Although investment costs for fuel cells are currently higher for traditional diesel backup solutions, these costs are expected to dramatically fall over the next 5 years as volumes increase and the technology further develops. This cost difference can be offset in the short term by the above-mentioned additional revenue opportunities of grid services or through saving money on electricity bills via peak shaving. With falling costs of fuel cell technology coupled with expected rising diesel fuel costs and carbon taxes in the future, the fuel cell is seen as a key technology for the decarbonisation of the backup power market for a range of customer segments including data centre, hospitals, and industrial applications.



CUSTOMER SEGMENTS

a) Data centres

Data centres are a mission critical application and highly reliant on a continuous, high quality and uninterrupted supply of power. Whenever the grid fails, data centres have to maintain full operation until the grid supply is reinstated. With very ambitious emission targets and a high importance placed on global reputation, data centres are one example of a customer segment which is already proactively considering green backup solutions with initial pilot projects coming into operation.

b) Hospitals, municipalities, industrial applications

Other customer segments like hospitals, industrial customers, transport hubs and municipalities also need to be protected from power outages by backup systems. This is particularly the case in areas with more unstable grids, for example due to extreme weather conditions, high renewable energy shares, or aged power plants and grid infrastructure. Many customers in these sectors are also looking to reduce carbon emissions and find clean alternatives for backup power, where diesel is currently used.

EXPLORING A SOLAR - HYDROGEN BASED COOKING SYSTEM FOR REMOTE, UNDEVELOPED AND BACKWARD COMMUNITIES IN INDIA

India faces formidable challenges in meeting its energy needs and in providing adequate energy. About 30% India's energy needs are being met through imports, which is likely to increase further in future. To eradicate poverty and deliver 8-10% economic growth rate, India needs to increase electrical generation capacity by 5 to 6 times of their 2003-04 levels. This requires enormous amount of expenditure. About two third of total electrical energy is generated by thermal power plants, where coal is the major fuel. Indigenous coal suffers from poor calorific value and result in high levels of pollution. Coal is likely to remain the most important energy source in the near future. However, search for a sustainable, pollution free, indigenous fuel for energy security is essential. Unfortunately, all known renewable energy sources such as solar are not yet reached a stage to meet growing demand.

India is a vast country with the second largest population in the world. More than two thirds of its population lives in rural areas. The rural population is widely spread and does not have easy access to LPG (Liquid Petroleum Gas) or natural gas pipeline as cooking fuel at affordable prices due to poor logistics. Furthermore, natural gas has limited reserves and may last for only few more decades. All existing cooking fuels such as wood, natural gas, biomass, kerosene etc. are also major contributors to pollution. At present, wood and cow dung are being used as fuel for cooking in rural India. It has resulted in fast depletion of our forests. In view of above, there is a need to search for a green, renewable, inexhaustible, economical and easily available alternate fuel to replace existing fuels for cooking application. Hydrogen meets these criteria, if it is made available in remote places, economical and is stored safely.

For remote and isolated communities, stand-alone distributed generation is of major relevance. Such a system has several advantages such as negligible transmission and distribution losses, lower capital cost, lesser gestation period, etc. ERDA is exploring the concept of a stand-alone Solar-Hydrogen based system for meeting the kitchen gas needs of isolated communities. This simple system consists of solar panels, an electrolyser, Hydrogen storage mechanism and Hydrogen delivery, which may be through pipeline or pressurised gas cylinder. The electrical output of solar panels is supplied to water electrolyser, which generates hydrogen and oxygen through electrolysis of water. Since the solar power is not going to remain throughout the day, the generated hydrogen can be collected in a pressure vessel. The collected hydrogen can be distributed either through a pipeline or pressurised cylinder to the community households depending upon economics, terrain etc.

Solar panels and electrolyser are commercially available and storage tank and hydrogen delivery system can be made as per specific location. The proposed system will become more economical with increase in capacity. The system is technically feasible, along with several other advantages such as energy security, job employment etc. This system has enormous potential to serve several other applications wherever heating, sintering and hydrogenation processes are involved. Similarly, oxygen is a by-product of this system, which can be used as combustion enhancer in metal/ chemical/ petrochemical industries, as bleaching agent (replacing chlorine in pulp/ paper industries), and to increase yield in aquaculture, etc.

We are increasingly seeing the potential of substituting the existing fossil fuel systems with Hydrogen based energy systems. Hydrogen has several advantages over other renewable energy sources and, owing to its neat and efficient burning properties is being considered as the fuel of the next generation. Its combustion does not produce any greenhouse gases, which makes it a viable and efficient alternative for various applications, including cooking. Thus, this Solar-Hydrogen based cooking system has the potential to be a great boon to India and would significantly help in energy independence for the nation.