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Editorial

# The Future of Sustainable Aviation Fuels, Challenges and Solutions

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The widespread COVID-19 epidemic and political instability worldwide caused a significant transformation in the world's fuel market. The invasion of Ukraine by Russia disrupted the flow of oil and gas among industrial nations that rely on them for manufacturing. The abrupt fall in petroleum supplies led to high gasoline costs at the pump. The continuing hostilities increased the demand for fuel as well as inflationary rates, both of which contributed to increases in the price of carbonised fuels. To successfully commercialize a suitable sustainable environmentally friendly replacement fuel, it is necessary to conduct research on the economic viability of alternative fuels. Hydrogen fuel appears to be a suitable alternative. It has zero-carbon emission, with water as the only byproduct. Researchers are exploring the development of new production methods that are sustainable and cost-efficient. Businesspeople are focusing on the logistics of moving, storing and promoting the use of this new fuel to usher in a new era in the fuel industry. In this Special Issue titled "The Future of Sustainable Aviation Fuels, Challenges and Solutions", we provide views of the study of hydrogen fuel from different perspectives and include contributions from different research areas, enforcing the interdisciplinary interest in the application of hydrogen. "The Future of Sustainable Aviation Fuels, Challenges and Solutions" includes eight papers covering different technological aspects, from the effect of the addition of hydrogen to natural gas in diaphragm gas meters [1]. The other papers are titled as follows: Reactivity Model as a Tool to Compare the Combustion Process in Aviation Turbine Engines Powered by Synthetic Fuels [2]; Proton Exchange Membrane Hydrogen Fuel Cell as the Grid Connected Power Generator [3]; Assessment of Energy Storage from Photovoltaic Installations in Poland Using Batteries or Hydrogen [4]; Designing an AB2-Type Alloy (TiZr-CrMnMo) for the Hybrid Hydrogen Storage Concept [5]; The Role of Hydrogen in Achieving Long Term Japanese Energy System Goals [6]; Cost-Economic Analysis of Hydrogen for China's Fuel Cell Transportation Field [7]; and Ammonia as Effective Hydrogen Storage: A Review on Production, Storage and Utilization [8].

A brief summary of the content associated with each of the selected papers in this Special Issue is included below.

Jacek Jaworski, Paweł Kułaga and Tomasz Blacharski [1], after conducting a durability test with natural gas mixtures having varying levels of hydrogen concentration (ranging from 0 to 15%), discovered that the obtained average drift of errors in the indications did not show any significant metrological differences between the gas meters that were tested. However, there was a significant metrological impact of the prolonged operation of gas meters on their errors of indications. However, this should not be considered as dependent on the hydrogen concentration in gas; rather, it should be considered to be dependent on the wear of the internal components of gas meters during the durability test. During durability tests, there was no evidence of any damage that may place the reliability of the operation at risk. After being subjected to the durability tests, each gas meter maintained its airtight seal. As a result, prior to the possible installation of thermal gas meters in Poland, the aforementioned issue had to be examined in minute detail, and the gas meters' appropriateness for measuring such gas combinations ought to be tested. Only then should the thermal gas meters be put into service.

Meanwhile, Tomasz Białecki et al. [2], using a test setup equipped with a tiny turbojet engine, reported that the combustion process was analysed and the results were interpreted. During the bench experiments, conventional jet fuel and its various mixes, including those with synthetic blend components produced from ATJ and HEFA technologies, were used. The experimental data that were acquired made it possible to build trend lines that were characterised by power functions, with the concentration of Carbon Monoxide (CO) serving as the dependent variable and the fuel mass' flow rate (mf) serving as the independent variable. A power function was created with a unique value of the parameter ($a$) and the exponent ($n$) for each of the mixes that were put through their paces. Using the universal reactivity model, one may create power functions that are similar to one another. However, the numbers that occur in the relationships that are constructed based on the reactivity model do have a physical meaning. This contrasts with the fact that the parameters of the trend line cannot be physically understood. Because of this, the generic reactivity model may be used to investigate the parallels and contrasts shared by several distinct combustion processes. After examining the correlation between $a$ values in power functions and the net heat of the combustion of the different blends that were tested, the researchers concluded that the combustion mechanism is different in situations in which the fuel is a mixture of Jet A-1 and HEFA and in situations in which the fuel contains an ATJ synthetic component. This was determined by comparing the two types of fuels to each other.

Koushik Ahmed et al. [3] found that if air pressure and fuel pressure dropped below a specific threshold, the proton exchange membrane hydrogen fuel cell as a grid-connected power generator proceeds to an unstable state. In order to prevent the electrical power supply from failing in its operational state, crucial points have been located and analysed. The fluctuation in fuel pressure had significant impacts on the overall efficiency of the system, in contrast to the low impact that the change in air pressure had on the overall efficiency of the system. The efficiency has a significant impact on the production of direct current electrical power by the PEMFC. DC electrical power created by the system is transformed through an inverter into AC power to feed the grid. Since the PEMFC is going to be the source of continuous electrical power generation for the planned system, there is no need for any form of energy storage. The findings of the simulation demonstrated that the suggested system could regulate the frequency of the voltage within a tolerance of $2 \times 10^{-5}$ Hz.

Bernard Knutel et al. [4] indicate that batteries are not the optimal approach, as shown by the findings of a study that compared the installation process with and without clean storage conditions. A much-improved impact is achieved by hydrogen storage, which, although having a lifetime that was far longer than 10 years, was still positioned below that of only installation. The non-storage method produced the best results in terms of economic efficiency. Nevertheless, this technique does not address the issue of maintaining the power system when energy demands are at their highest or when there are other pressing circumstances. As a result, the influence on the economy should not be the sole factor considered when making decisions. Installations that include storage provide additional benefits. This includes the resolution of a common issue associated with renewable energy sources, where the energy produced is prone to large fluctuations and is difficult to predict, regardless of whether there is a demand for it.

Julián Puszkiel et al. [5] developed a plan to design a material for use in a hybrid reservoir. The reservoir itself was the subject of the plan. A non-stoichiometric AB2 C14 Laves alloy and ENG were used to create a material composed of (Ti0.9Zr0.1)1.25Cr0.85Mn1.1Mo0.05 + 10 wt% ENG. This material has ideal hydrogen storage qualities. It has the appropriate thermodynamic stability (almost 20 kJ/mol $H^2$), acceptable equilibrium pressures to operate in the region between 0 °C (Peq.des. = 14 bar) and 85 °C (Peq.abs. = 248 bar), 1.5 wt% of hydrogen capacity and abs./des. times of 25 and 70 s, respectively. In addition, the material exhibited improved thermal characteristics when subjected to decreased high-pressure applications at 250 bar in conjunction with a fuel cell. The suggested hybrid system displayed a hydrogen volumetric and gravimetric density of 19 kg $H^2/m^3$ system and 1.8 wt%, respectively, while operating at a lowered pressure of 250 bar and with a filling degree material of 60%. This was accomplished using a filling degree material.

Anshuman Chaube et al. [6] reported that the success of key industries of storage, supplementing gas grids, power generation and transportation, appears to be contingent on the implementation of three key stimulatory policy approaches. These include the setting of ambitious targets, carbon-pricing regimes and investments in both low-emission technologies and the research and development that underpins them. In terms of the necessary future energy mix, a need has been identified for a further transition away from fossil fuels toward renewable energy. Additionally, a need has been identified for the incorporation of existing carbon neutral nuclear generation assets in order to meet Japanese INDC commitments. Both needs are necessary to support a hydrogen economy. The results that were modelled for Japan tended to support a significant transition away from fossil fuels and toward renewable energy, with a minor contribution from nuclear in the short- to mid-term. Consequently, the study and synthesis of the results appear to project a positive outlook for the development of such an energy system. While the storage, gas grid replenishment and transportation sectors look to be favourable to hydrogen replacing or supplementing current infrastructures, there are still some unanswered problems about the electricity production sector. The research answered the question of why hydrogen import costs are important for the development of a viable hydrogen economy in Japan.

Zixuan Luo et al. [7] said that, by 2030, China's hydrogen fuel consumption will surpass 5 million tonnes. Obtaining low-cost hydrogen will be vital to unlocking China's fuel cell transportation sector. High-purity hydrogen fuel is expensive. Large-scale hydrogen generation is mostly from fossil fuels (coal and natural gas). In the future, environmental constraints will lead to greater hydrogen purification regulations and higher carbon trading costs. Fossil fuel hydrogen prices will rise. Small-scale onsite hydrogen generation via water electrolysis is possible. Costs are not determined by purification but by electricity. Renewable power may lower the cost of producing hydrogen from water electrolysis. The costs of hydrogen energy, hydrogen transportation and carbon trading are modelled. When mechanisms related to power and carbon trading improve in the future, they can be used to lower the price of hydrogen. On one hand, the cost of electricity as a raw material for making hydrogen can be cut by participating in electricity market-oriented and cross-regional transactions. On the other hand, businesses that make hydrogen from electrolyzed water can lower total costs by selling extra carbon emission rights via carbon trading. The market for hydrogen is growing quickly; hence, the amount of hydrogen will rise accordingly. The cost of storage and the effects of different uses of hydrogen energy, trading systems, centralised production and distributed production must be considered.

Muhammad Aziz, Agung Tri Wijayanta and Asep Bayu Dani Nandiyanto [8] found that hydrogen is seen as a possible future secondary energy source (or energy carrier). Hoewver, because hydrogen has a very low volumetric energy density when it is a gas at room temperature and pressure, it needs to be stored and moved in a way that makes the most of its high density in both mass and volume. Ammonia is better than the other mediums, especially in terms of how hydrogen can be stored, transported and used. The authors examine how ammonia is made, stored and used. Some of the most important technologies are explained. Even though the Haber–Bosch process is a well-known method for making ammonia, electrochemical processes for making ammonia appear to be better choices for the future because they use less energy. When it comes to storage, ammonia has many advantages over other hydrogen storage methods because it can be kept as a liquid in mild conditions, such as propane. The infrastructure and rules for storage and transportation of ammonia are well-defined. Lastly, ammonia is used in many different technologies, such as internal combustion engines, turbine combustion and fuel cells. Ammonia fuel cells with direct feeding are thought to be efficient in terms of how much energy they use overall. Further research on how to make and use ammonia more efficiently needs to be undertaken.

As reported by Yusaf et al. (2022) [9,10], urgent actions are needed to speed up the use of renewable energy, the exchange of hydrogen and ammonia and the management of energy systems. Problems with the ammonia economy become important, especially when it comes to putting it into the energy system. However, ammonia has potential. Turning renewable energy into ammonia (called "renewable ammonia") is a possible sustainable future fuel.

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