

Fuels of the future

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Abstract

This paper examines methods of fuel production using alternative approaches compared to current reliance on fossil fuels. The goal is economically viable and environmentally friendly energy production.

The proposed methods include chemical reactions, solar energy, heat generation using TEG (Techno Electric Generator) systems, and biodegradable mass. Some of these methods have already been implemented (Toyota Mirai, Artemis II), but they are not yet fully developed.

Further research should lead to solving the problem of liquid hydrogen leakage from hydrogen storage tanks, improving the efficiency of hydrocarbon oxidation—which is currently around 50%—as well as developing environmentally sustainable solutions.

Keywords: alternative fuels; hydrogen production; thermoelectric generators; biomethane; energy recovery

1. Introduction

The future is impossible to imagine without cars, aircraft, or some other form of transportation. We often hear that flying cars will be produced in the future, which is not impossible, or that a new type of vehicle will be developed. In all of this, a major question arises: "How will fuel for these means of transportation be obtained?"

This current issue is a problem of today, but it may also become a problem in the future. We are witnessing high oil prices, which indirectly drive economic crises. The issue of fuel could lead to even greater problems if it is not addressed in time.

In this paper, you will learn about the types of fuels that exist and the ways in which they can be produced. Some fuels are already known, but cannot be applied in practice due to certain limitations. The goal is to find solutions for the most efficient and economical fuel of the future by considering the existing literature and pointing out the shortcomings.

2. Literature review

The scientific literature provides an overview of the following methods of fuel production, which are considered to form the basis of future energy systems.

2.1. Hydrogen

Hydrogen is considered the most promising fuel of the future and is therefore extensively studied. It can be produced in various ways: by partial oxidation of hydrocarbons (Demirci, 2015), coal gasification (Rand and Dell, 2009), and steam methane reforming (Sharma et al., 2021).

These methods are based on extracting hydrogen from fossil fuels. The steam methane reforming method produces, in addition to hydrogen, the toxic gas CO, which is a greenhouse gas, as well as additional impurities that can be filtered out, but harmful compounds still remain in the environment. Partial oxidation of hydrocarbons is a very inefficient method (around 50% efficiency). Coal gasification is a more promising approach, achieving about 97% pure hydrogen efficiency, while causing less environmental pollution.

On the other hand, hydrogen can also be produced by methods that do not involve extraction from fossil fuels. These include electrolysis (Yildiz and Kazimi, 2006), solar energy (Ursúa et al., 2011), and thermochemical methods (Acar and Dincer, 2013).

The mentioned solutions are more efficient, with efficiencies ranging from 70% to 90% (Sharma et al., 2021). The electrolysis method is already well known: electricity splits water molecules into hydrogen and pure oxygen. The drawback of this method is the high processing cost. This approach can be combined with solar energy, where the electricity required for electrolysis could be generated using solar panels that convert sunlight into electrical energy. However, this solution is not equally effective everywhere, since electricity generation depends on the level of solar radiation in a given location.

The third method is the thermochemical method, which is less efficient because heat can be converted into electrical energy that is then lost during thermochemical cycles. The principle behind this conversion is the Seebeck effect, in which a temperature difference between two different conductors or semiconductors generates an electric voltage. This phenomenon enables the direct conversion of thermal energy into electrical energy without moving parts, making it suitable for applications in demanding conditions (Snyder and Toberer, 2008).

2.2. Artemis II

Oxygen was already used as fuel in the Artemis II project. Its main problem was that hydrogen was stored in liquid form, which occupies less volume than the gaseous state but can gradually escape from the tank due to the very small size of its molecules.

As a solution, the use of composite material containers in which hydrogen would be stored under high pressure is proposed. Potential new storage materials include alkali-metal aluminum hydrides doped with titanium (Bogdanović and Schwickardi, 1997). Another issue is the extremely low temperature of -253°C , which is difficult to achieve. Refueling must be carried out using robotic arms or other mechanical devices, as it is impossible for humans to withstand such low temperatures without technological assistance.

2.3. 2.3. Conversion of engine heat into energy

This method is already known in the automotive industry. It is based on converting a car's waste heat into energy that can be used to power the vehicle. Heat from the engine, exhaust system, and air conditioning would be utilized by TEG (Thermoelectric Generator) units to convert thermal energy into electrical energy.

Research has shown that, instead of a square shape, it would be more efficient to install a concentric cylindrical TEG using a ring-shaped thermoelectric module, thereby also taking advantage of heat pipe technology (Huang, K., Yan, Y., Li, B. et al., 2018).

This option is particularly suitable for hybrid vehicles, as at lower speeds the car could draw electricity from the battery and operate on it. It is also a good solution for city cars, which typically cover shorter distances.

2.4. Biomethane from algae

Another possible solution is the production of biomethane using algae. Methane is a component of oil, a non-renewable and consumable energy source. This is not a new fuel, but rather a different way of producing the same compound. Under controlled conditions, algae could generate biomass that would decompose in the absence of oxygen. This process produces biomethane and carbon dioxide. The carbon dioxide could be released into the atmosphere, where it would be utilized by plants in photosynthesis. This method yields over 90% biomethane, is environmentally friendly, and does not harm the natural environment.

3. Methodology

The literature used in the paper provides clarifications of the mentioned terms and processes. By referring to previous works, this work gets a scientific basis and grounding.

3.1 Highly efficient energy recovery system

By studying and comparing different approaches, it can be concluded that some proposed fuel solutions are, in theory, a kind of perpetual motion machine of the first kind, based on the first law of thermodynamics. However, perpetuum mobile is not possible in practice, so it is better to call this system a highly efficient energy recovery system. One example is the reverse electrolysis method. It operates by taking oxygen from the atmosphere and using already-produced hydrogen obtained through the previously mentioned processes. By combining them, energy is generated to power the vehicle. Based on the reverse electrolysis principle, the Toyota Mirai vehicle was developed. As a byproduct, water is produced, but it is technical water (not suitable for drinking). Technical water contains impurities and traces of metals that can pose a significant risk to human health. Therefore, it is most commonly used for mechanical processes (such as irrigating green spaces, flushing systems, and cooling industrial machinery).

In theory, this water could be subjected again to the electrolysis process. The electricity required for this could be generated using solar panels, separating hydrogen once more, which would then be recombined with oxygen. In this way, water circulates through the system, although the amount of hydrogen would gradually decrease.

The idea of TEG generators is, in a way, also a form of highly efficient energy recovery system. The vehicle utilizes its own heat to generate energy. Since heat is produced during the operation of the vehicle, it could theoretically generate electricity as long as it is moving. The drawback is that high speeds could not be achieved (up to about 60 km/h).

4. Results and Discussion

Fuel solutions are numerous; some are efficient, some are not economically viable, but they do exist. Certain methods have already been implemented at an industrial level such are, for example, Toyota Mirai and Artemis II.

Methods based on fossil fuels, such as methane steam reforming and coal gasification, although technically developed and currently the most widespread, show significant

disadvantages in terms of carbon dioxide emissions and other polluting gases. Although coal gasification achieves high efficiency in hydrogen production, its environmental impact remains negative, which limits its long-term sustainability.

On the other hand, water electrolysis stands out as the cleanest method of hydrogen production, because it produces only hydrogen and oxygen as by-products. However, its application is limited by the high consumption of electricity, which significantly affects the overall economic profitability, especially if the energy is not obtained from renewable sources. The integration of electrolysis with solar energy is a potential solution, but its effectiveness depends on local climatic conditions and the availability of solar radiation.

Thermoelectric systems, which convert waste heat into electricity, represent a promising direction of development in the field of energy efficiency. However, their current limitations in terms of conversion efficiency and high material costs prevent wider application. Similarly, thermochemical processes offer the possibility of direct conversion of thermal energy into electricity, but require further technological development to become competitive with conventional methods.

Biological approaches, such as biomethane production from algae, show high potential in terms of sustainability and reduction of carbon dioxide emissions. These systems enable the use of CO₂ as a raw material, thus contributing to the circular economy and reducing industrial emissions. However, their commercial application is still in the early stages of development and requires optimization of growing conditions and yields.

5. Conclusion

Based on the research, we conclude that there are several options that could replace current fuel, oil. Most future fuels rely on electricity (TEG) and energy production. In the methods described above, it can be observed that hydrogen is used as an intermediary for producing energy that powers vehicles.

We come to the conclusion that fuels are essentially the same in composition, but are obtained in different, less conventional ways. Special attention should be given to methods that are environmentally friendly and do not harm the natural environment, such as biomethane production.

Through the process of electrolysis, pure oxygen is obtained, which could contribute to the restoration of the ozone layer, although this depends on solar activity, i.e. UV radiation. Most of the oxygen is retained in the troposphere. A small part of it can reach the stratosphere, where under the influence of UV rays, an oxygen atom (O) will be created, which will react with an oxygen molecule (O₂) and form ozone (O₃). This method can slightly increase the ozone concentration. Also, carbon dioxide from algae could enhance the photosynthesis process, thereby benefiting nature.

The goal is also to develop an economical method of fuel production that would be easily accessible to people. In this way, future economic crises could be avoided or at least reduced.

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