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Alternative Clean Energies as Fuel Sources for Urban Transportations System (APA style)

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***Abstract*:** Over the past few decades, climate change has become increasingly serious. As the earth's temperature rises, glaciers will gradually melt, causing sea levels to become higher and higher, which will make seaside land submerged by the ocean, and many species will become extinct because they lose their habitat (May & Inc. Encyclopedia Britannica, 2008). The Intergovernmental Panel on Climate Change (IPCC) appeals to protect the environment and keep the temperature rise within 1.5°C (Intergovernmental Panel on Climate Change, 2018). However, only relying on people or the government is far from enough to save natural resources spontaneously and reduce pollution. Solving the problem of climate change requires technological development. One of the main causes of climate change is large amounts of greenhouse gases. Greenhouse gas absorbs the energy reflected from the ground (Montzka et al., 2011), which means increased levels of greenhouse gas will warm the surface of the earth. Approximately 20% of global carbon dioxide emissions come from automobile exhaust emissions (Sierra at al., 2019). To reduce excessive greenhouse gas emissions, the emission of car exhaust must be reduced. Therefore, this paper aims to find which alternative energy solution would be the best to incorporate into the urban transportation system.

Keywords: New Energy; Clean Energy; Climate Change

Introduction

Many companies, scholars, or countries have proposed theories to build prototypes or tested solutions to reduce vehicle emissions. China strongly supports the new energy vehicle (electric vehicle or hybrid electric vehicle) industry (Zhang et al., 2021). For example, BYD in China and Tesla in the United States have established new energy vehicle factories in China.

As the cleanest fuel, hydrogen energy is also a major trend of new energy resources. Hydrogen bus technology has been developed successfully in Germany and Japan, and there were about 50 prototypes before 2009 (Schlapbach, 2009). The "An integrated electricity-hydrogen-gas system"(p.1) proposed by Wei et al. (2021) can minimize the cost with carbon constraint, which is conducive to developing the hydrogen energy system and the energy saving of the existing transportation system.

The use of wind energy has a long history. Some scholars have proposed that wind energy can be stored by pumping water to a relatively high reservoir (Liu, 2014). Fathabadi et al. (2019) proposed embedding wind turbines in vehicles to reduce the energy loss of vehicles.

The rest of the paper will review and analyze the potential solution of each energy mentioned.

1. Potential Solutions

1.1 Hydrogen Vehicle

Hydrogen is a great choice to replace fossil fuel to reduce greenhouse gas. Since hydrogen combustion only yields water, hydrogen energy is one of the cleanest energy sources in the world (Armaroli & Balzani, 2011). What's more, hydrogen also has the advantages of high calorific value and excellent combustion performance. Hydrogen is one of the fuels with the highest calorific value, almost three times that of oil. (Moller et al., 2017) Therefore, hydrogen is hailed as one of the most valuable new energy sources in the 21st century.

While hydrogen vehicles use hydrogen as fuel, hydrogen vehicles' principle is different from oil-fueled vehicles. Current oil-fueled vehicles use internal combustion engines to burn the fuel chemically to generate heat energy and then convert that heat energy into mechanical energy. The efficiency improvement of internal combustion engines is restricted by the Carnot cycle (Schlapbach, 2009). Hydrogen vehicles work completely differently; these vehicles use hydrogen fuel cells which burn hydrogen electrochemically to generate electricity (Schlapbach, 2009). However, hydrogen vehicles have the possibility of higher efficiency, and the product of the reaction is only water. Therefore, hydrogen vehicles are not only pollution-free and efficient, but also have a lower fire risk due to the fast volatilization of hydrogen (Schlapbach, 2009).

Despite these advantages, many problems restrict the development of hydrogen vehicles. The first problem is that there is no economically feasible method to produce large amounts of hydrogen, because the catalysts of traditional hydrogen production methods are too expensive (Esposito et al, 2010). Since the traditional hydrogen production process also produces a large number of greenhouse gases, one functional alternative would be to set up a large number of bioreactors to produce hydrogen. Photoheterotrophic plants, algae, will produce hydrogen under certain conditions and do not release greenhouse gases in the process (Kolbe & Fischedick, 2020). Therefore, we can build many "algae farms" to produce enough hydrogen for the hydrogen energy industry. The optimal depth of the bioreactor for hydrogen production is 5cm (Zhang et al. 2015). If the bioreactor, whose volume is 0.2L, uses Chlorella sp, one type of algae, the hydrogen production rate is 2.14´10-5kg·L-1h-1 (Song et al., 2011). By calculation, the area of a bioreactor is 0.004m2. The Toyota Mirai has a capacity of 5kg (Kolbe & Fischedick, 2020). To fully Toyota Mirai's tank, it needs 2.3´104 bioreactors of 0.2L, which is about 92m2, to produce hydrogen full day (10 hours).

2. Wind Energy Vehicles

Wind energy, as one of the famous distributed energy, is another promising potential solution. Wind energy vehicles become another potential solution, Wind energy is one of the most promising clean energy. The wind energy reserves are large and widely distributed, but the energy density is low and unstable. The history of human use of wind energy can be traced back thousands of years (Sathyajith, 2006). Nowadays, there are a large number of wind power plants built in Xinjiang, China. And wind power generation in many countries' accounts for more than 1% of the total power generation (Sathyajith, 2006).

Unlike thermal power plants, current wind power plants have high uncertainty (Sathyajith, 2006). Due to the uncertainty of wind power generation, wind power plants often have high requirements on the regulation and control ability of a region's power grid. Therefore, we embed wind turbines directly in new cars instead of directly using energy from wind power plants, which can reduce dependence on the grid (Noman, 2020).

Wind energy vehicles use natural wind energy and the wind energy generated when the vehicle is running to reduce energy consumption. Theoretically, when the car is moving, the air blowing to the car drives the wind turbine to generate electricity, and its cost is nearly free (Fathabadi, 2019). When the car is stopped, the wind turbine also converts natural wind energy into electric energy in the car. Wind energy vehicles can use the air flowing to the car to cool the car's engine, which can also reduce the use of coolant.

3. Hybrid Electric Vehicles and Electric Vehicles

Compared with the last two new energy vehicles, the technology of electric vehicles and hybrid vehicles has matured and entered the market for a while. Electric vehicles are vehicles that directly use electrical energy to generate mechanical energy. Hybrid electric vehicles are that added batteries to the oil-fueled vehicles to reduce fuel consumption.

Current hybrid electric vehicles and electric vehicles have been proven to have a great positive impact on reducing exhaust emissions (Hu et al., 2021). What ‘s more, hybrid electric vehicles and electric vehicles also surpass oil-powered vehicles of the same price in many aspects of vehicle performance, such as fast acceleration of vehicles. Due to the awakening of people's environmental awareness and the support of some national policies, the market share of hybrid electric vehicles and electric vehicles is increasing. (Zhao et al., 2021) Therefore, hybrid electric vehicles and electric vehicles are also one of the trends in new energy vehicles.

Given that the current hybrid electric vehicles and electric vehicle technologies are relatively mature, the main goal for the development of hybrid electric vehicles and electric vehicles is to electrify more vehicles， and to build more charging piles in cities. Technically, it is to improve the performance of the battery.

Hybrid electric vehicles and electric vehicles may not be the best new energy vehicle solution, but it is definitely the best transitional solution.

4. Analysis of Solutions

4.1 Hydrogen Vehicle Applications

In the previous section, we mentioned the use of hydrogen vehicles and the construction of many “algae farms” to produce hydrogen for hydrogen cars. However, for hydrogen vehicles, hydrogen storage technology is also a significant problem. Hydrogen is gas, and when stored at room temperature, the mass of hydrogen fuel is not enough to supply a driving car. The storage system needs to be compressed and cooled to about -250 degrees Celsius to make hydrogen vehicles available (Schlapbach, 2009).

There are two main types of hydrogen storage technologies. One method physically absorbs hydrogen using some materials with high surface area, such as graphite. Under ideal conditions, these materials can absorb about 8% of the adsorbent mass of hydrogen. Nevertheless, in order to achieve this state, it may be necessary to lower the system temperature below -200 degrees Celsius, which is also unrealistic (Schlapbach, 2009).

Another hydrogen storage technology is chemical adsorption. Hydrogen has strong reducibility and can react with many metals or alloys, and most of these reactions are reversible reactions. However, most materials chemically adsorb too little hydrogen, or the temperature required to release hydrogen is too high (Schlapbach, 2009).

Algae farms can significantly reduce the cost of hydrogen production and the release of greenhouse gases. However, the cost of producing hydrogen is still high. First, to ensure that the enzymes that convert hydrogen are not inactivated, the farm needs to move these bioreactors to a sulfur-free medium, which is labor-intensive (Kolbe & Fischedick, 2020). Moreover, these algae have high requirements for space and the environment, which increase land consumption and cost. It is calculated that a developed city needs to build algae farms with a total area of about 92 square kilometers, which is too large.

4.2 Wind Energy Vehicles Applications

The primary problem with wind energy utilization has always been instability (Sathyajith， 2006). Not only the wind turbine’s location but even the wind direction will significantly affect the efficiency of wind energy utilization. Only when the wind direction is opposite the generator can the wind energy utilization rate reach the highest efficiency (Fathabadi, 2019). However, when the wind direction is perpendicular to the wind energy generator, the wind energy utilization rate is 0 (Wang & Liu, 2021). Although the wind direction is fixed when the car is moving (almost always blowing from the front of the car), when the car's speed is low, the electricity generated by wind energy will not be sufficient to support the energy consumption of the entire car.

When a vehicle is moving, it is often difficult to constantly move forward at a constant speed. The changing wind speed will significantly damage the battery and wind turbines and even the entire battery system. In reality, through experiments, the wind power system has only increased by 0.2% (Fathabadi, 2019), which is far from meeting our requirements for new energy vehicles.

If wind energy vehicles with sufficiently high efficiency are developed, wind energy vehicles still have other restrictions. Modern wind power plants often have to separate each wind power generator by a certain distance. (Gagakuma, 2021). The traffic conditions in the city are too complicated, because there are often traffic jams or accidents. If wind energy vehicles are put into the market on a large scale, it is ineffective that filling the tank of a hydrogen car requires the 92 m2 algae bioreactor to work for 10 hours.

4.3 Hybrid Electric Vehicles and Electric Vehicles Applications

While the technology for electric vehicles and hybrid electric vehicles seems mature, and while research shows that electric vehicles and hybrid electric vehicles have a direct and significant relationship with improving air quality, these two models also have their problems.

The mainstream electric vehicle models currently on the market can't drive for a long distance. However, the primary constraint on the development of electric vehicles and hybrid electric vehicles is the battery. As the United States is a "country on wheels", the driving distance limit and the long charging time will cause significant troubles for people, especially those who need to travel across states or interstate transportation.

Another significant issue is that the battery is not adaptable to extreme weather. (Liu et al., 2021) Oil-fueled vehicles generally only need to be warmed up in winter before they can be driven. However, for electric vehicles, the start and stop of the battery in winter often damage the battery itself. This has a significant impact on the service life of electric vehicles.

The aging of the battery will also affect the service life of electric vehicles. The aging of the battery will increase the battery's internal resistance, which will increase the energy consumption of electric vehicles. According to experiments, when the battery works for 24 months, the internal resistance of the battery increases by 71% (Stroe et al., 2018). If people need to replace electric cars frequently, this will significantly increase greenhouse gas and pollution emissions.

Hybrid electric vehicles seem to combine the environmental protection of electric vehicles and the convenience of petrol cars, but hybrid electric vehicles have higher traffic conditions and speed requirements. According to experiments, Toyota Yaris, a hybrid electric car, can achieve a fuel consumption of 0L/100km only at a speed of 50km/h. When the speed exceeds 50km/h, the gasoline fuel consumption is almost the same as that of the exact specification oil-fueled car. When the road or traffic conditions are complicated, the vehicle's fuel consumption will also increase significantly. (Ivanov et al., 2019)

The electricity consumed by electric vehicles and hybrid electric vehicles often needs to be obtained by burning fossil fuels. Experiments show that energy has a tremendous negative impact on the carbon emission performance of the new energy automobile industry (Zhao et al., 2021). Therefore, electric vehicles and hybrid electric vehicles cannot solve the current problem of excessive greenhouse gas.

Conclusion

Climate change is a pressing matter that requires public consensus and collective actions. Reducing CO2 emission as one of the solutions to tackle the problem has a strategic advantage in that cities can put forward policies on a city level to encourage or demand behavioral shifts. Transportation regulation offers a great opportunity for countries to take initiative and move the society towards a clean, more efficient and more developed state.

Each clean energy options all have their pros and cons. For example, hydrogen vehicles are held back by the gas form nature of its fuel. Safe and efficient storage of enough hydrogen as an energy source demands the gas chamber to be compressed and cooled to an extremely low temperature threshold, none of which is practically possible in a moving vehicle. The high cost of production also does not help either. Wind energy is tricky to handle due to its sensitivity towards the wind input. Another problem the wind turbines and battery combination faces is the unstable speed changes that may severely damage the battery system. The most well received alternative energy, by process of elimination, seems to be electric vehicles with hybrid energy sources.

References

[1] Armaroli, & Balzani, V. (2011). The hydrogen issue. ChemSusChem, 4(1), 21–36. https://doi.org/10.1002/cssc.201000182.

[2] Esposito DV, Hunt ST, Stottlemyer AL, et al. Low-cost hydrogen-evolution catalysts based on monolayer platinum on tungsten monocarbide substrates. Angewandte Chemie (International ed). 2010;49(51):9859-9862. doi:10.1002/anie.201004718.

[3] Fathabadi. (2019). Possibility of utilizing wind turbine to recover a portion of the kinetic energy losses of a car. IEEE Transactions on Vehicular Technology, 68(9), 8663–8670. https://doi.org/10.1109/TVT.2019.2931192.

[4] Gagakuma B, Stanley APJ, Ning A. Reducing wind farm power variance from wind direction using wind farm layout optimization. Wind engineering. 2021;45(6):1517-1530. doi:10.1177/0309524X20988288.

[5] Hu, H., Zhang, Y., Rao, X., & Jin, Y. (2021). Impact of technology innovation on air quality—An empirical study on new energy vehicles in China. International Journal of Environmental Research and Public Health, 18(8), 4025. https://doi.org/10.3390/ijerph18084025.

[6] Intergovernmental Panel on Climate Change. (2018). Global Warming of 1.5 ℃.

[7] Ivanov, Y., Ivanov, R., KAdikyanov, G., Staneva, G., & Danilov, I. (2019). A study of the fuel consumption of hybrid car Toyota Yaris. Transport Problems, 14(1), 155–167. https://doi.org/10.21307/tp.2019.14.1.14.

[8] Kolbe, Lechtenböhmer, S., & Fischedick, M. (2020). Hydrogen derived from algae and cyanobacteria as a decentralized fueling option for hydrogen powered cars: Size, space, and cost characteristics of potential bioreactors. International Journal of Sustainable Transportation, 14(5), 325–334. https://doi.org/10.1080/15568318.2018.1547935.

[9] Liu T, Zhang M, Wang YL, et al. Engineering the surface/interface of horizontally oriented carbon nanotube macrofilm for foldable lithium‐ion battery withstanding variable weather. Advanced energy materials. 2018;8(30):1802349-n/a. doi:10.1002/aenm.201802349.

[10] May RM, Inc. EB. Climate Change. 1st ed. Encyclopaedia Britannica, Incorporated; 2008.

[11] Moller, Jensen, T. R., Akiba, E., & Li, H. (2017). Hydrogen——A sustainable energy carrier. Progress in Natural Science, 27(1), 34–40. https://doi.org/10.1016/j.pnsc.2016.12.014.

[12] Montzka SA, Dlugokencky EJ, Butler JH. Non-CO2 greenhouse gases and climate change. Nature (London). 2011;476(7358):43-50. doi:10.1038/nature10322.

[13] Noman, Alkahtani, A. A., Agelidis, V., Tiong, K. S., Alkawsi, G., & Ekanayake, J. (2020). Wind-energy-powered electric vehicle charging stations: Resource availability data analysis. Applied Sciences, 10(16), 5654–. https://doi.org/10.3390/app10165654.

[14] Sathyajith. (2006). Wind Energy Fundamentals, Resource Analysis and Economics (1st ed. 2006.). Springer Berlin Heidelberg. https://doi.org/10.1007/3-540-30906-3.

[15] Schlapbach. (2009). Technology hydrogen-fuelled vehicles. Nature (London), 460(7257), 809–811. https://doi.org/10.1038/460809a.

[16] Song, W., Rashid, N., Choi, W., & Lee, K. (2011). Biohydrogen production by immobilized Chlorella sp. using cycles of oxygenic photosynthesis and anaerobiosis. Bioresource Technology, 102(18), 8676–8681. doi:10.1016/j.biortech.2011.02.082.

[17] Stroe, Swierczynski, M., Kar, S. K., & Teodorescu, R. (2018). Degradation behavior of lithium-ion batteries during calendar ageing—The case of the internal resistance increase. IEEE Transactions on Industry Applications, 54(1), 517–525.

https://doi.org/10.1109/TIA.2017.2756026
[18] Wang Z, Liu W. Wind energy potential assessment based on wind speed, its direction and power data. Scientific Reports. 2021;11(1):16879-16879. doi:10.1038/s41598-021-96376-7.
[19] Wei X, Zhang X, Sun Y, Qiu J. Carbon emission flow oriented tri-level planning of integrated electricity-hydrogen-gas system with hydrogen vehicles. IEEE Transactions on Industry Applications. Published online 2021:1-1. doi:10.1109/TIA.2021.3095246.
[20] Zhang, D., Dechatiwongse, P., del Rio-Chanona, E. A., Maitland, G. C., Hellgardt, K., & Vassiliadis, V. S. (2015). Dynamic modelling of high biomass density cultivation and biohydrogen production in different scales of flat plate photobioreactors. Biotechnology and Bioengineering, 112(12), 2429–2438. doi: 10.1002/bit.25661
[21] Zhao, M., Sun, T., & Feng, Q. (2021). A study on evaluation and influencing factors of carbon emission performance in China's new energy vehicle enterprises. Environmental Science and Pollution Research, 28(40), 57334–57347. https://doi.org/10.1007/s11356-021-14730-8.