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Blue: A Hydrogen-fueled Drone Delivery System for Medical Services in Smart Cities

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***Abstract*— This paper will present a business model that aims to function within the parameters of the third, twelfth, thirteenth, and seventeenth sustainable development goals, which are "good health and well-being," "responsible consumption and production," "climate action," and "partnerships for the goals." The use of drones for medical deliveries is a promising solution to improve the efficiency and speed of medical supply chains. This paper proposes Blue, a company that utilizes hydrogen fuel-powered drones to transport medical supplies. The proposed system is designed to overcome the limitations of traditional delivery methods, such as traffic congestion and time delays, by providing a more reliable and efficient transportation system. Blue Company uses drones equipped with a hydrogen fuel cell, which produces electricity to power the drones. For safe and effective delivery, the drones have GPS and a real-time monitoring system. The suggested technology is built to function in a smart city setting, enabling effective routing and delivery. Our findings demonstrate that the drug delivery system is successful in enhancing patient access to healthcare and lowering carbon emissions in urban settings.**

Keywords*— medical delivery, hydrogen fuel drones, last-mile delivery, data analysis, route optimization.

I. INTRODUCTION

Recently, the research community has been more interested in small electric drones as a result of their expanding use in numerous industrial applications. They are capable of a wide range of tasks thanks to their various tools and sensors, including monitoring and inspection [1], delivery [2], agriculture [3], wireless coverage [4], and handling the COVID-19 pandemic through social distancing monitoring [5], thermal imaging, and sanitization [6]. They also have the additional benefit of having good operational traits, including great mobility, dependability, efficiency, minimal thermal traces, and quiet operation.

Hydrogen can be used as a fuel in the transport sector to power vehicles through fuel cells that convert hydrogen into electricity, emitting only water as a byproduct. This technology can be particularly useful in smart cities, where reducing emissions and improving air quality are major priorities.

One use case for hydrogen in smart cities is for public transportation systems such as buses, trains, and taxis. Hydrogen fuel cell vehicles have a longer range and faster refueling times compared to battery electric vehicles, which can make them more practical for public transport in cities. Additionally, hydrogen fuel cell buses and taxis have been successfully deployed in several cities around the world, such as London, Paris, and Tokyo.

Another use case for hydrogen in smart cities is for goods transportation, especially for delivery trucks and vans. Hydrogen fuel cell vehicles will play an important role in reducing emissions and improving air quality in smart cities, particularly for public transportation.

Using hydrogen as a fuel in the transport sector in cities is important for several reasons, including reducing greenhouse gas emissions, improving air quality, enhancing energy security, supporting innovation and economic growth, and enabling long-distance travel. Overall, using hydrogen in transport in cities is important because it can help address environmental, health, energy, and economic challenges while also providing sustainable and innovative transportation options for urban residents and businesses.

The hydrogen transport business ecosystem involves various players and stakeholders, including hydrogen producers, fuel cell manufacturers, vehicle manufacturers, infrastructure providers, governments and policymakers, research and development organizations, industry associations, and advocacy groups. The key players and stakeholders in the hydrogen transport business ecosystem work together to develop and promote the use of hydrogen as a fuel for transport, from hydrogen production and fuel cell technology to vehicle manufacturing and infrastructure development.

The deployment of hydrogen transport in smart cities requires a coordinated effort between governments, industry, and research organizations to develop a strategy, build infrastructure, deploy vehicles, and monitor and evaluate the impact.

To capture the value of hydrogen in transport, it is important to take a strategic approach. This includes identifying revenue sources, developing business models that capture the value of those revenue sources, and creating partnerships with other stakeholders in the hydrogen transport ecosystem. It also involves developing policies and regulations that support the growth of the hydrogen transport market, such as incentives for the deployment of hydrogen vehicles and infrastructure and regulations that ensure the safe operation of hydrogen transport systems.

Adapting emerging technologies into novel businesses is a challenge. Business model creation and the investigation of numerous innovative businesses are presented in [7]–[10]. Technology deployment to support the United Nations Sustainable Development Goals is also presented in detail in

[11]–[14]. 40 different hydrogen business cases are investigated in detail in a recent working paper [15].

II. Methodology

A. Drone technology

The Blue is a hydrogen-powered VTOL (vertical takeoff and landing) drone. Unlike traditional drones that require a runway or launchpad, these drones can take off and land vertically, making them ideal for use in urban or mountainous areas where space is limited. The drone also features a GPS navigation system that uses satellite signals to accurately determine its location and guide its flight path.

In addition to its VTOL design and GPS navigation system, the Blue drone is also equipped with advanced safety features that help ensure the secure and reliable delivery of medical supplies. For example, it is designed to automatically detect and avoid obstacles in its flight path, using a combination of sensors and sophisticated software algorithms to assess the environment around it and adjust its trajectory accordingly.

The drone is equipped with a high-resolution camera that can capture real-time video and images of its surroundings, allowing for precise monitoring of the delivery of medical supplies.

The VTOL design of the drone includes multiple rotors and a stabilizing system that enable it to take off and land vertically, making it highly maneuverable and efficient in its operations [16]. It is an unmanned aerial vehicle (UAV) that uses hydrogen as a power source to generate electricity for the motor..

B. Hydrogen fuel

To launch the Blue, hydrogen fuel is used. Hydrogen full-cell system equipment is integrated into the body of the drone. The system consists of a stack of fuel cells that convert hydrogen fuel into electricity, which is then used to power the drone's electrical motor. The hydrogen regulator provides the necessary pressure regulation and a controlled and safe supply of hydrogen from the cylinder to the fuel cell power module [17]. The hydrogen cylinder is a high-pressure tank that stores hydrogen. Then, in an electrolyte inside a full-cell power module, oxygen and hydrogen have a reaction that forms electrical power for an electrical motor. The output of this reaction is only water [18].

Hydrogen fuel cell systems have several advantages over traditional batteries, including longer flight times, faster refueling, and reduced weight. Additionally, hydrogen fuel cells produce only water as a byproduct, making them a cleaner and more sustainable option for drone operations. This system can also carry heavier payloads than traditional battery-powered drones. This is because the weight of the fuel cells is less than the weight of the batteries required for an equivalent flight time. The use of hydrogen fuel cells in the Blue drone not only provides a longer flight time and greater payload capacity but also contributes to a cleaner and more sustainable environment.

C. system flow

The mobile app receives an order from a customer. After that, the blue system determines the availability of a working drone from the central storage location. Once a working drone is identified, medical supplies are loaded with the customer's order from the storage area. Then it is loaded onto the drone and secured for transport. Then, the Blue's GPS navigation system is programmed with the delivery destination and flight path. Once the drone takes off, the hydrogen fuel cell system provides power to the electrical motor, enabling the drone to fly for an extended period without the need for frequent recharging. If there is no malfunction or damage to the drone, it is loaded back into the storage area for future use. If there is a malfunction or damage to the drone, it is sent to the drone maintenance team for repairs.

In addition to flight, the drone's camera captures real-time video and images of the delivery area, allowing for precise monitoring and navigation. Once the drone arrives at its destination, it uses its VTOL capabilities to land vertically, ensuring a safe and accurate delivery. The medical supplies are then unloaded from the drone with a robotic arm and distributed to those in need. Fig. 1 schematizes the blue delivery system flow.

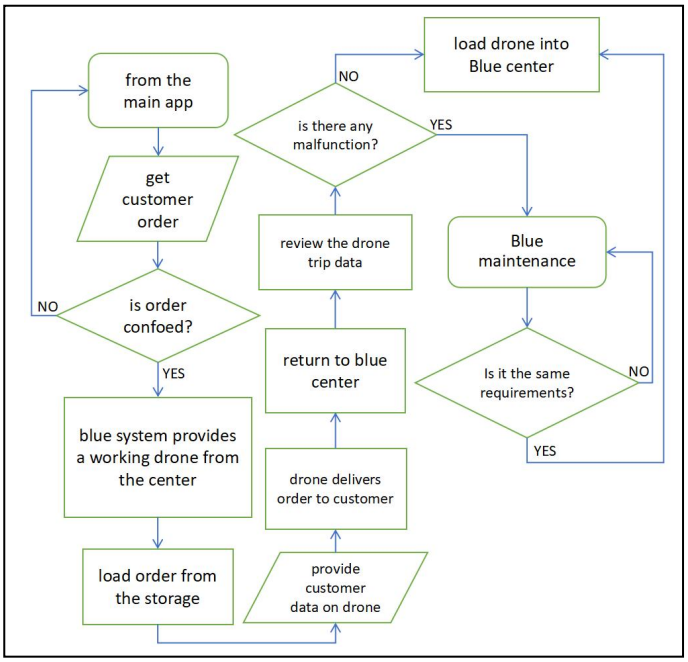

Fig. 1. Blue delivery system flow.

III. System Design And Business Model

A. Business model canvas

Business Model Canvas, Division A Nine main headings on the company's canvas illustrate how we should view our purpose [19]. The studies examine similar business models in detail [9].

- Key resources

The company's employees, consisting of engineers, designers, developers, and other professionals, provide the knowledge and expertise necessary for the development and maintenance of the drone system. Drone data, allowing the company to optimize its operations and improve drone performance. also brand, mobile app, and trademark rights.

- Key activities

Blue's primary objective is to provide medical delivery services through its drone delivery system. To ensure that the drones are operating at optimal performance. Blue designs and manages the maintenance of the drones. Partner management with medical factories, hospitals, pharmacies, and hydrogen fuel companies .

- Value proposition

We operate 24/7, enabling us to provide rapid and high-quality delivery of medicines and treatment. We are committed to cost savings for our clients and provide our delivery services without harming the environment by using hydrogen fuel cells and the ability to reach remote locations, providing medical aid where it is needed most.

- Customer relationship

We prioritize customer relationships and strive to provide excellent service at all times. We offer multiple channels for customers to reach us, including contact numbers, a web page, and a mobile application. We value customer feedback and provide a comments and complaints section to address any concerns promptly. We believe in building long-term relationships with our customers by providing a seamless experience and personalized service.

- Customer segment

hospitals and pharmacies, clients who are depending on timing for medicines and supplies, and partners with pharmaceutical factories and medical places, as when a new disease appears, there is a need to transport samples or vaccines without human intervention to avoid infection .

- Channel

Blue's center and branches, along with its online presence through social media, mobile applications, and its website And by digital marketing and Google Ad-words.

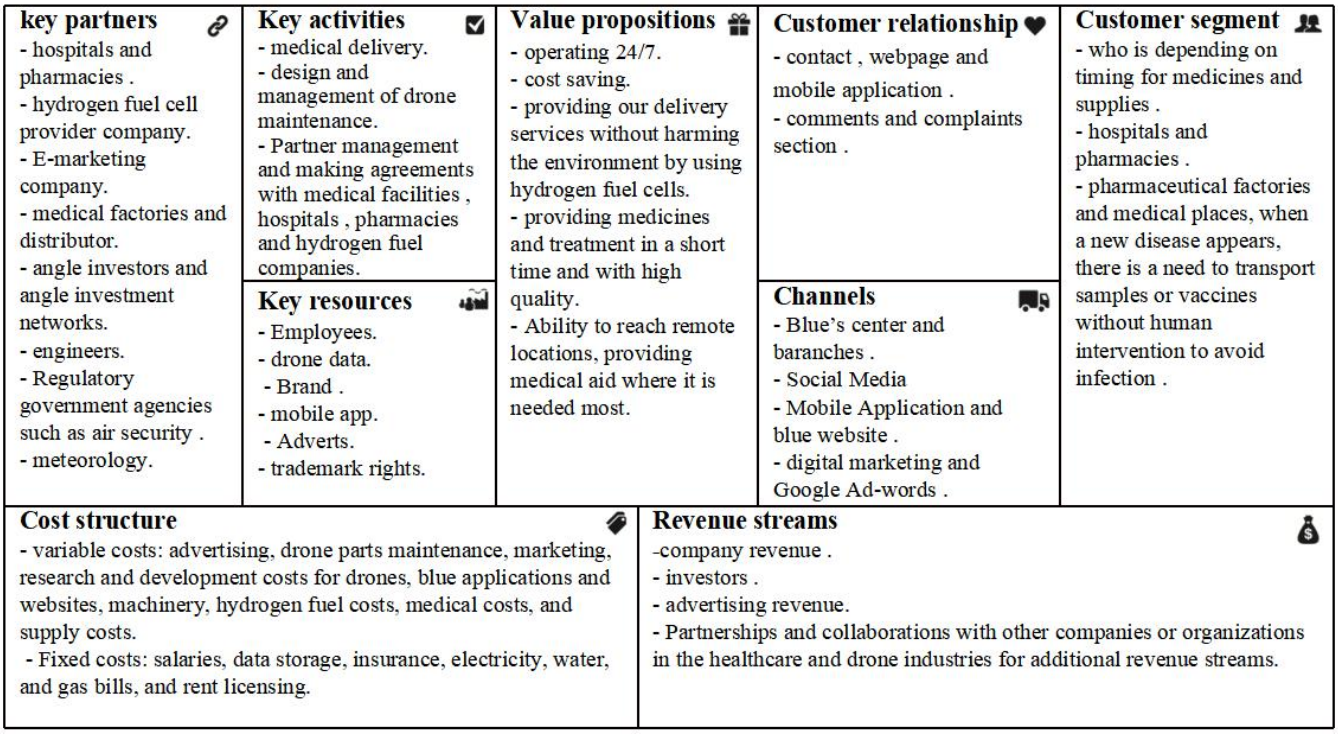

Fig. 2. Business model canvas of Blue.

B. Eco system

Blue's kapital comes from investors, and the customers are mainly hospitals and pharmacies, but we can accept home delivery as well, as long as delivery requests are provided in a timely manner and with high quality. Register the delivery trip, and we get the cash for the delivery, and part of the profits are paid to the investors while keeping 70% within the company.

The internal services start in the drone manufacturing department, then go to the shipping department located in the center, where they will be fueled and loaded with the orders. The medication within the required form, and when the drone takes off, the control department follows it up and provides it with orders and the location. This department also writes notes or reports problems and sends them to the development and maintenance departments.

Blue cooperates with several other companies through annual contracts, including the hydrogen fuel company to obtain the fuel needed for blue drones and pharmaceutical companies and distributors to obtain the medicines that our customers need, such as pills, glucose meters, vaccines, etc. Information is also obtained from meteorology to determine the delivery time and from the air security of the city to obtain information according to the laws and methods of flying unmanned drones. [7].

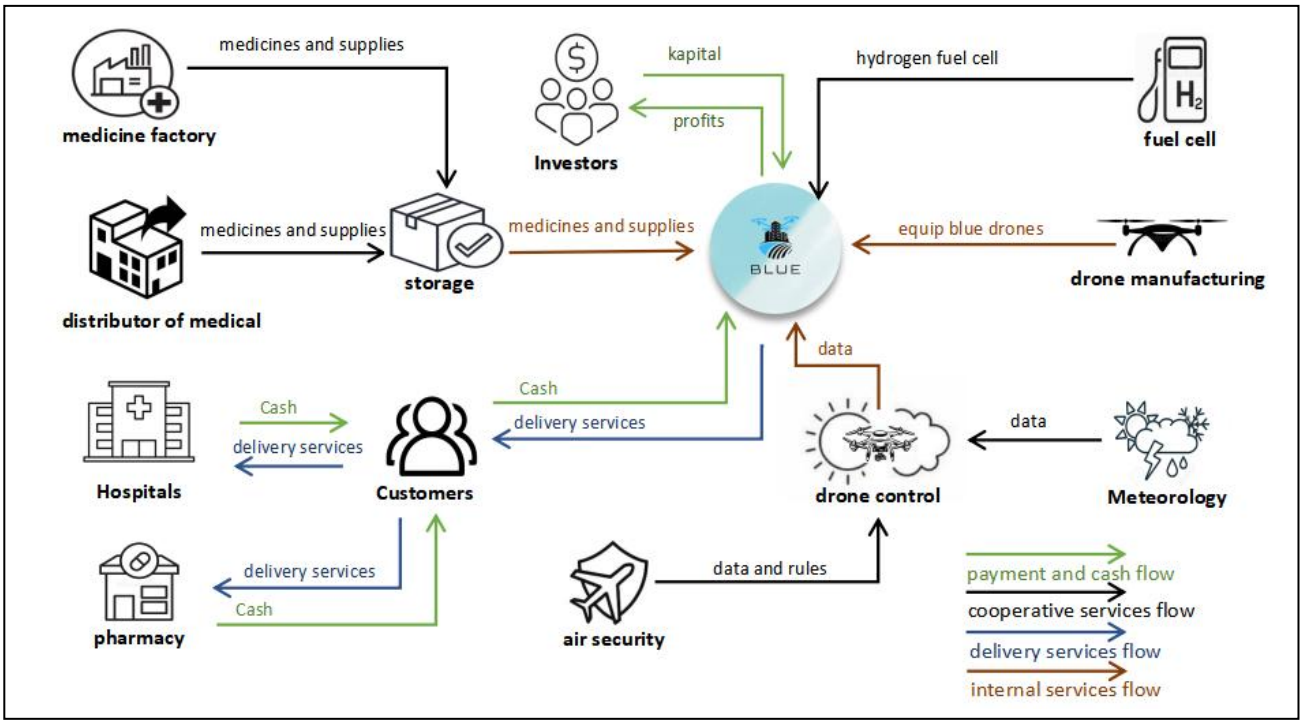

Fig. 3. Eco system of Blue.

C. *The value of Blue*

Enhancing customer value improves customer satisfaction and experience. The values in our company are social value, environmental value, and business value (Figure 4). The definition and types of value are discussed in detail in the studies [14], [20], [21], and [22].

• The social value:
Improved access to healthcare for patients who depend on timely access to medication, reduced traffic congestion, increased efficiency in operating 24/7 and delivering medicines directly without intermediate stops, safety by complying with all relevant regulations and safety standards, and competitive advantage by being an adopter of hydrogen fuel can provide a competitive advantage over traditional delivery companies.

• The environmental value :
Hydrogen fuel is a clean and renewable energy source that produces only water as a byproduct, so we reduce carbon emissions compared to traditional methods that rely on fossil fuels, improve air quality by reducing the number of delivery trucks on the road, reduce air pollution and improve air quality, which have a positive impact on public health, and reduce noise pollution because drones are quieter than delivery trucks.

• The business value :
The phrase "business value" refers to all types of value that have a long-term impact on the health and viability of our company. Our company, Kapital, will be funded by debt and equity. The dividends are paid by keeping 70% of the cash inside the company and leaving 30% for the investors. And by increasing revenue by providing faster and more efficient delivery services, we attract more customers and increase revenue.

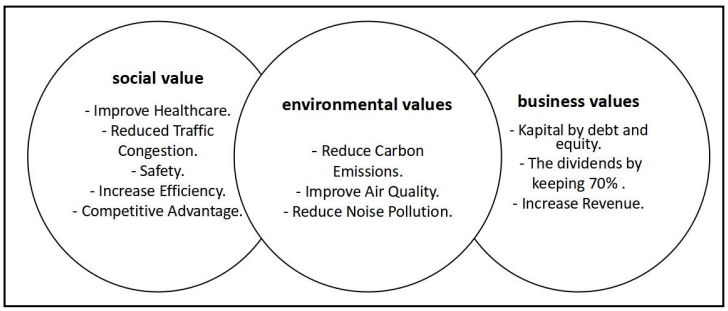

Fig. 4. The value of Blue.

D. *Similar companies and the summary of business model*

The idea of using hydrogen fuel for drones and other applications is being explored by several companies, such as Wingcopter [23], Dynamics [24], and Heven Drones [25], and their summary of business models is in Figure 5.

Company/ Project (Field)	COUNTRY	Value Proposition (What?)	Targeted Customers (Who?)	Value Creation/Value Delivery (How?)	Value Capture/ Revenue Model
Wingcopter, Wingcopter 198. WINGCOPTER	Germany.	A drone manufacturing and drone delivery company that provides private solutions to its customers.	It serves businesses and organizations and has been used in various projects around the world, including delivering COVID-19 vaccines and medical supplies in Africa and transporting blood samples in Scotland. It has also been used for environmental monitoring and wildlife protection in Indonesia and for delivering parcels in Australia.	The Wingcopter 198's ability to carry payloads of up to 6 kilograms makes it suitable for transporting small parcels and packages, which can be especially useful in areas with limited road access. its unique capabilities as a hybrid drone that can take off and land vertically like a quad-copter and transition to forward flight like a fixed-wing airplane. This allows it to fly longer distances and carry heavier payloads than traditional quad-copters.	Tom Plümmer, Jonathan Hesselbarth, and Ansgar Kadura founded Wingcopter in 2017. They help reduce the time required to access often vital supplies from days down to hours, and often even minutes. As an aviation company, we operate both as a manufacturer of aviation-grade drone technology and as a service provider for a wide range of drone deployments.
H^3Dynamics Hycopter . H³Dynamics	Singapore.	«Building the future of commercial drone services by combining machine learning, remote tele-robotics, and off-grid capability».	organizations and businesses involved in environmental monitoring and surveying. This includes government agencies responsible for wildlife management and conservation, as well as non-governmental organizations (NGOs) and private companies involved in environmental research and monitoring.	By using hydrogen fuel cells to power the electric motor and propellers, the Hycopter is able to achieve flight times of up to 4 hours, which is significantly longer than most battery-powered drones. This extended flight time enables the drone to cover large areas and gather more data, which can be critical for environmental monitoring and surveying applications.	The company was founded in 2015 . It is a Singapore-based company. the revenue model of the Hycopter is based on the sale of the drone and associated services.
Heven Drones, H2D55. HEVEN DRONES	The Israel.	«To develop actionable, multipurpose drones that solve everyday problems from autonomous last-mile delivery to emergency response and infrastructure repair ».	The Heven Drones aim for multiple industries to enhance and support defense missions, infrastructure maintenance, emergency response, last-mile deliveries, and more.	A hydrogen-fueled drone was developed by Heven Drones. The innovative H2D 55 Drone boasts 5x longer flight times, operates in more extreme conditions, and utilizes sustainable energy with a reduced carbon footprint, as compared with traditional battery-powered drones.	The company was founded in 2017 by Bentzion Levinson. They are reimagining what drones can do. Instead of machines that simply inspect and monitor, they are developing multitasking robots that increase efficiency, lower costs, and save lives.

Fig. 5. SIMILAR COMPANIES AND THE SUMMARY OF BUSINESS MODEL

IV. SUSTAINABLE DEVELOPMENT GOALS

The 17 fundamental Sustainable Development Goals were created by the member nations of the United Nations. It went into effect in 2016 and is expected to attain its goal in 2030. The planet and humanity's ability to live in peace and prosperity are its main goals [26].

This business model aims to operate within the parameters of four Sustainable Development Goals:

• SDG 3: is addressed by delivering medicines to hospitals and pharmacies. By helping improve access to healthcare over time, Blue will help achieve healthcare goals and promote good health and well-being for all.

• SDG 12: is addressed by using hydrogen fuel cells, which produce only water as a byproduct and do not harm the environment. Blue is promoting sustainable production and consumption patterns by using hydrogen fuel. Also, the delivery of medicines is an essential service, and the use of drones reduces waste and increases delivery efficiency.

• SDG 13: is addressed through lowering carbon emissions in urban settings, which contributes to the global effort to combat climate change. Blue is reducing its carbon emissions and promoting clean energy by using hydrogen as a fuel, and the only output is water. The use of drones also reduces noise and the need for traditional transportation methods.

• SDG 17: is addressed through partner management with medical factories, hospitals, pharmacies, and hydrogen fuel companies, which is essential for the success of the proposed business model. The delivery of medicines requires collaboration between various stakeholders, including hospitals, pharmacies, and Blue.

Fig. 6. Sustainable development goals of Blue.

V. Results

The suggested system aims to overcome the drawbacks of traditional delivery techniques by offering a more dependable and effective transportation system using unmanned aircraft fitted with hydrogen fuel cells.

Access to healthcare for patients is improved through the drug delivery system.

Drones powered by hydrogen can potentially fly for longer periods of time and emit no pollutants, although they are currently more expensive to manufacture and require longer fueling times. Drones that run on batteries, on the other hand, have shorter flight times, a higher initial cost, and a slower recharging time. They may also unintentionally emit emissions.

The use of hydrogen in urban transportation, the paper's conclusion, is crucial because it may aid in resolving issues related to the environment, human health, energy use, and the economy, while also giving city residents access to new and sustainable transportation options.

VI. Conclusions

One of the main advantages of hydrogen as a fuel is its potential to minimize emissions to zero with the right technology and application. Hydrogen fuel cells are a more efficient and reliable power source for drones than traditional electric batteries or combustion engines.

While research on drones and fuel cells has been done separately, integrating these technologies to produce fuel cell drones requires further exploration and development. This paper emphasizes the importance of hydrogen in the urban transportation sector and its potential benefits in reducing greenhouse gas emissions, improving air quality, and supporting innovation and economic growth.

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