Land Transportation-Aviation-Maritime Technology Symposium 2024

Innovations and Disruptive Technologies Shaping Transportation

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Accelerating Innovation in Rail and Road Transport

Section 1: Introduction and Opening

Good morning, honourable speakers, distinguished guests, ladies, and gentlemen. I am deeply honoured today to speak before my mentors, friends, fellow engineers, and experts.

Today's symposium covers technologies adopted in land, air and sea travel. I would like to focus on land transport and hence title my speech as "Accelerating Innovation in Rail and Road Transport". Before we jump into today's topic, let us warm up together to have a feel of speed on the development in autonomous vehicles.

In recent years, we have witnessed the leaps in autonomous vehicle technologies around the world, driven by rapid development and innovation in the industry. These cutting-edge technologies hold the promise of enhancing road safety by eliminating human errors and optimizing the use of limited road space. In our country, at least 16 cities were released for testing of autonomous vehicles, being the world largest "Laboratory" for this technology. The development is accelerating. For example, in Wuhan, where the Baidu Apollo robotaxi service expanded from 5 to 300 robotaxis within the last year 2023, they plan to further expand their fleet with a thousand of robotaxis by the end of this year.

The aforementioned example of accelerated innovation of autonomous vehicles stems from advancement in technologies such as computing power, artificial intelligence, and connectivity. The acceleration of autonomous vehicle development is further bolstered by

supportive government policies, which include the establishment of trial areas, the creation of regulatory frameworks, and the provision of financial assistance. Lastly, the collaboration between the public sector, professional institutions, and industry pioneers has significantly contributed to the flourishing of the technology.

Section 2: Innovative Hydrogen Powered Transport

Likewise, another innovative technology of rail and road transport is the utilization of hydrogen fuel. The synergy between technology development, government policy and collaboration around the world has been the key driver behind the progress in this field. Our country has firmly established hydrogen-powered transport as a key target in the national decarbonization strategy. Hydrogen is regarded as an important component of the national energy system in achieving our country's target of carbon neutrality.

Now, when I say "new" hydrogen technology, I'm talking about the groundbreaking advancements happening all around us, which refers to innovative developments and advancements in hydrogen production, transportation, storage, and utilization. Let's see how we are going to make it.

Section 3: Four "New Challenges" of hydrogen technologies

As the old Chinese saying goes "萬事起頭難" or "Everything is difficult at the beginning". In line with this timeless wisdom, I am going to talk about the "New Challenges" we are facing in hydrogen technologies, followed by the sweet parts, i.e. how we deal with them by "innovation".

(i) To explore new sources of green hydrogen at reasonable price

The first challenge is we need “green hydrogen at a reasonable price.”

According to the International Energy Agency (IEA), global hydrogen production reached almost 95 million tonnes in 2022. Nevertheless, there was less than 1 million tonnes of green hydrogen produced, i.e. less than 1%.

The International Renewable Energy Agency (IRENA) revealed that the current production cost of green hydrogen is USD 4-6 per kg, which is 2-3 times more than that of grey hydrogen.

Due to the scarcity of supply and high production cost, the majority of hydrogen fuel consumed is grey hydrogen which is not satisfactory from carbon reduction point of view. We have to explore new source of green hydrogen in order to increase the supply and lower the price. I’ll share more details later

(ii) New means of storage/ transportation

The second challenge we are facing is the storage and transportation of hydrogen. Upon production, hydrogen has to be stored and transported to locations of end use, such as hydrogen refueling station. For its storage and transportation, the low volumetric density of hydrogen under ambient conditions, which is about 10 000 times less than that of diesel, causes much trouble to the task.

Today, high-pressure gaseous hydrogen tube trailers, with storage pressure between 200 bar to 300bar, are the mainstream hydrogen transportation medium. However, using tube trailers to transport compressed hydrogen is expensive due to the heavy storage cylinder weight and each tube trailer can only carry a small amount of hydrogen with respect to the gross vehicle weight. Typically, a hydrogen tube trailer, with weight of 44

tonnes, can only be used to refuel 15 hydrogen buses. While a diesel tanker, with weight of just 25 tonnes, can refuel approximately 50 diesel buses. According to the China Hydrogen Alliance (中國氫能聯盟), hydrogen tube trailers are only cost-effective for short distances of hydrogen transportation up to 150km.

For large-scale and long-distance application, other new means of storage and transportation have to be explored and developed. I would share with you some key information in later section.

(iii) New utilization of hydrogen fuel

After talking about the new challenges on aspects of production, storage and transportation, let's move on to another major challenge, the "utilization". Some of you might be familiar with the fast-developing hydrogen fuel cell vehicle and its extensive applications in heavy-duty trucks and buses, particularly in demonstration cities of our country, such as Beijing, Shanghai and Guangzhou. Some of you, like me, might even have the opportunity to get a test ride on these hydrogen powered vehicles. Perhaps, you may share my feeling that the ride was sensational.

Yet, our quest for green and cheap energy never stops here!

To accelerate the speed of achieving carbon neutrality and the growth of the hydrogen industry, we need new application of hydrogen fuel in other transport modes and industries. Apart from hydrogen powered vehicles, more utilizations should be explored to expand the demand of hydrogen across different sectors.

(iv) New technologies of hydrogen production

The fourth, but not the least challenge, is on the hydrogen production technologies. Green hydrogen production mainly relies on electrolysers powered by renewable energy. However, the efficiency of the electrolysers nowadays is merely around 66%. Obviously, there is still some room for improvement in the electrolyser efficiency to lower the price of green hydrogen.

Section 4: How does the world accelerate the innovation of hydrogen industry

After talking about the challenges, we come to the exciting part, the acceleration of hydrogen technology. According to the Hydrogen Council, there were only about 200 hydrogen projects worldwide in 2021. Among these projects, the mature investment, i.e. the projects have actual plans or have already been realized, was just worth for US$ 80 billions. By this year, this number has increased to more than 1,400 projects. The mature investment has grown to US$310 billions. This demonstrates that momentum for hydrogen technology continues to accelerate. I'm going to highlight some of them and share where we are up to, and what we are going to do.

(i) Hydrogen Production: Green hydrogen production plants

Hydrogen is recognised as an ultimate clean energy source and a secondary energy carrier. As the world increasingly focuses on greener energy solutions, the production of green hydrogen has become the highest priority for energy storage. One notable achievement is the commissioning of the world's largest green hydrogen production plant in Xinjiang powered by a 300MW solar farm with a production capacity of 20,000 tonnes per year. This project is a milestone in our country's green hydrogen development, demonstrating our commitment to innovation and sustainable energy solutions.

In addition to solar-to-hydrogen production, innovative methods such as waste-to-

hydrogen technologies are gaining traction. For example, at the other side of the world, Thiozen's project in Alberta, Canada, focuses on producing clean hydrogen from "sour gas" waste. This approach not only provides a sustainable source of hydrogen but also addresses waste management issues, demonstrating the potential for diverse hydrogen production methods.

These projects exemplify the global commitment to expanding green hydrogen production and illustrate the diverse approaches being adopted worldwide, to achieve a more sustainable future.

(ii) Transportation of Hydrogen: West-to-east hydrogen pipelines

On transportation of hydrogen, the current primary method involves hydrogen tube trailers, which transport compressed hydrogen by road. This method, while effective for shorter distances and smaller quantities, has limitations in scalability and efficiency.

Looking ahead, significant advancements are being made in the transportation of hydrogen. For example, there are already around 5,000 km of hydrogen pipelines in operation worldwide, mainly in the United States and Europe, connecting refineries and chemical complexes. There are also projects to retrofit existing natural gas pipelines for hydrogen transmission.

Our country is also building the first west-to-east hydrogen pipeline (西氫東送), which will transport green hydrogen over 400 km from Inner Mongolia to Beijing. This pipeline will enhance cross-region hydrogen transmission, showcasing our country's pioneering role in large-scale hydrogen infrastructure and significantly contributing to our country's goal of decarbonization.

Additionally, the transportation of liquid hydrogen is becoming a viable option for international trade. For instance, the super-cooled liquid hydrogen, down to -253°C, in a bulk of more than 1,000 m^3 is being transported from Australia to Japan, demonstrating the potential for long-distance and large-scale hydrogen transport. This method involves cooling hydrogen to cryogenic temperatures to convert it into a liquid state, allowing for more efficient transportation over long distances.

(iii) Storage: Solid-state hydrogen storage

For storage of hydrogen, our country has achieved a new milestone in solid-state hydrogen storage and launched the first solid-state hydrogen storage project last year in Guangzhou, which overcomes the difficulties of flexible conversion between unstable renewable power and green hydrogen. Most importantly, it is expected to solve the technical bottleneck of storing hydrogen in solid form using alloy material under normal temperature conditions.

(iv) Utilization: Japan and Korea's successful demonstration on blending hydrogen in power generation; World's breakthrough of land and maritime transport

Technology breakthrough is not only on the supply side, but also on the demand side. Prepare to be amazed, as the world of power generation may have been forever transformed! Japan's Mitsubishi Heavy Industries recently tested a massive gas turbine with a blend of 30% hydrogen and 70% natural gas, marking a world-first with its 566 MW output. Not to be outdone, South Korea's Hanwha Group successfully ran an 80 MW gas turbine on 100% hydrogen fuel. These feats signal a revolutionary shift in power generation!

For land transport, CRRC Cháng Chūn Railway Vehicles unveiled a hydrogen-powered

urban train in March this year. This train demonstrates higher energy efficiency than their electric counterparts, consuming only 5 kWh per kilometer compared to the 6-7 kWh used by electric trains. This improved efficiency sets a new standard in rail transit, showcasing hydrogen's potential as a more energy-effective alternative to traditional electric power in railway systems. It could also get rid of the overhead power line.

We have also seen the potential of hydrogen fuel on the sea, a Norwegian ferry operator launched the world's first liquid-hydrogen powered ferry, which is able to carry up to 300 passengers and 80 vehicles showcasing hydrogen's transformative potential in maritime transport.

These advancements highlight hydrogen's versatile and critical role in shaping a sustainable future. The hydrogen revolution is here, and it's truly exciting!

(v) R&D: Breakthrough of electrolyzer efficiency

As I mentioned earlier, the widely adopted electrolyzer technologies have typically operated at efficiencies of around 66%. A recent breakthrough by an Australian company (Hysata) holds the potential to redefine the landscape of green hydrogen production. With its innovative electrolysis design, underpinned by its proprietary capillary technology, can now achieving an exceptional efficiency of 95%. A trial project funded by the Australian Government will scale-up and manufacture a modular commercial 5 MW electrolyser to test and verify the new technology. This transformative advancement represents a significant leap forward surpassing IRENA 2050 target (i.e. 90%), offering the prospect of cost-effective, scalable, and sustainable hydrogen production.

Section 5: How does Hong Kong help our country to accelerate innovation

We, Hong Kong, possesses many competitive edges, such as our unique role of one country two systems, well established legal system, global financial and business hub, etc. What can we do in accelerating the process of innovation?

(i) Collaboration among government B/Ds - "Inter-departmental Working Group on Using Hydrogen as Fuel"

Frankly speaking, it's always been a problem that legislation lags behind technology development. Likewise, there has been no specific legislation for hydrogen fuel to facilitate the development and trial use of hydrogen fuel in Hong Kong. To provide a fast track to the hydrogen fuel development, the Government established an Inter-departmental Working Group on Using Hydrogen as Fuel two years ago. The Working Group consists of 13 government policy bureaux and departments of different aspects. Various government bureaux and departments have collaborated to provide a one-stop-shop service to the industry facilitating the trial projects on hydrogen fuel.

Our department, EMSD, has been providing support to the Working Group and the industry in electrical, mechanical and gas safety to take forward the hydrogen fuel development in Hong Kong.

(ii) Collaborating with international consultants, the Greater Bay Area and professional institutions to establish standards

To prepare for the deployment of hydrogen fuel in Hong Kong, EMSD, in collaboration with other Government departments, international consultants, professional institutions, the Guangdong–Hong Kong–Macao Greater Bay Area and other stakeholders, has conducted detailed studies on risk analysis, especially on the Risk Assessment of Hydrogen-Fueled Vehicles in Tunnels, and published three technical standards, including

code of practice for hydrogen-fuelled vehicles and maintenance workshops, code of practice for hydrogen refuelling stations, and guidance note on quantitative risk assessment study for hydrogen installations. These interim standards taking account of the technical requirements of our national standards and international standards, with additional features to suit our environment of highly dense city, will facilitate the rapid and safe development of hydrogen technology in Hong Kong.

Meanwhile, we are also working on the establishment of a certification system for "Green Hydrogen" which would be the first of its kind in the world. Through the collaboration with the State Administration for Market Regulation (國家市場監督管理總局 or SAMR), we aim to extend these standards to the "Bay Area Standard" and "Bay Area Certification". By establishing clear, consistent standards, we can ensure the safe and effective use of hydrogen fuel, fostering greater innovation and adoption across the Greater Bay Area.

(iii) Showcases of projects: hydrogen light rail and 3-axle double-decked hydrogen bus

Inspired by the Mainland's success, Hong Kong has already made significant strides to create an enabling environment conducive to the development of hydrogen fuel through the aforesaid Working Group. Let's dive into the exciting trial projects that are paving the way for hydrogen energy in Hong Kong.

The trial of hydrogen light rail in Tuen Mun, this initiative involves a six-month trial of a low-floor hydrogen tram on a designated route. Manufactured by CRRC qīng dǎo sì fāng, it features six hydrogen storage tanks and can travel at speeds up to 70 km/h. This trial is more than just a test; it's a demonstration of our commitment to green technology and a symbol of Hong Kong's potential as a leader in sustainable transport solutions.

Another project is equally groundbreaking: the world's first three-axle double-decked hydrogen bus. Produced in the Mainland, successfully passing the stringent vehicle examination in Hong Kong to prove it's roadworthiness and hydrogen safety. This bus has set to be showcased in Australia and is now operating in Hong Kong. This project highlights Hong Kong's role as a showcase for global hydrogen technology, attracting attention and investment from around the world.

In June this year, we saw the collaboration of Veolia Hong Kong and Towngas to launch Hong Kong's first green hydrogen production project! They're going to use the landfill biogas to produce green hydrogen and production is expected to kick off as soon as next year with daily production capacity of around 330 kg of green hydrogen. That's enough to power around eight hydrogen buses for a full day. Can you imagine the environmental impact this is going to have? It's a total game-changer for sustainable transportation in Hong Kong. I'm so excited to see this innovative project get off the ground.

(iv) Establishing a robust regulatory framework for hydrogen fuel

Building a solid regulatory framework is essential for any new technology. The Gas Safety Ordinance (Cap. 51), which has successfully regulated LPG, Towngas, and natural gas for over 30 years, provides an excellent foundation. By amending Cap. 51 to include hydrogen fuel, we can leverage our existing expertise to regulate the entire hydrogen supply chain, from importation and manufacturing to storage and use. Our goal is to present the amended Ordinance to the Legislative Council by early 2025, ensuring a robust legal framework that supports innovation while prioritizing public safety.

A comprehensive regulatory framework does more than just ensure safety; it also provides clarity and instills confidence in investors and developers. We, in Hong Kong, take pride

in being the first region worldwide to adopt a dedicated Ordinance specifically for regulating the use of hydrogen as fuel. This robust regulatory framework enables us to lead the way for other regions or countries, serving as a trailblazer and pathfinder (领頭羊 lǐng tóu yáng). By spearheading these green regulatory frameworks, we can further solidify our country's status as a global leader in sustainable technology.

(v) Supporting market expansion with professional services and funding

Innovation requires not only technology but also support systems that enable the growth of the market. Hong Kong's professional services sector can play a pivotal role in this regard. Through the Green Tech Fund (GTF) and the New Energy Transport Fund (NET Fund), we are providing substantial financial support for research and development in green technologies.

Moreover, Hong Kong's professional services can assist hydrogen enterprises in expanding internationally. By offering comprehensive technical, financial, and regulatory support, we can help these companies navigate global markets. This two-pronged approach — bringing in international expertise and expanding our own technologies abroad (「引進來」、「走出去」yǐn jìn lái zǒu chū qù) — leverages Hong Kong's strengths as a global financial and business hub. Our professional services sector is uniquely positioned to support the growth of hydrogen technology, attracting foreign investment, creating jobs, and further solidifying Hong Kong's status as a global leader in innovation.

Section 6: Closing

President Xí Jìn Píng proposed in September last year the idea of developing "New

Quality Productive Forces"（新質生產力）. The term "New" in "New Quality Productive Forces" is inherently tied to the idea of innovation, which plays the leading role **(以科技創新為引領)** and features high-tech（高科技), high efficiency（高效能）and high quality（高品質）and comes in line with the new development philosophy.

As reflected on the innovative strides I shared today, it's evident that "新質生產力" or "New quality productive forces", is not just a concept, but a vital force driving and accelerating the transformation of our transportation systems.

President Xi reiterated in June this year that "New Quality Productive Forces" are intrinsically the "Green Productive Forces"（新質生產力本身就是綠色生產力。). China strives to peak carbon emissions before 2030 and achieve carbon neutrality before 2060, with innovations in hydrogen development serving as a prime example of these 'Green Productive Forces.' The advancements in hydrogen-powered vehicles and infrastructure we see globally, and particularly in our country and Hong Kong, are testaments to this new era of productivity through innovation.

Together with the technology of autonomous transportation, the futuristic scenes we've seen in movies might become a reality. Just picture it, a hydrogen-powered autonomous vehicle running on a street of Hong Kong, or even a hydrogen-powered autonomous train gliding over the Victoria Harbour in our future. These are not distant dreams but achievable realities, driven by the innovative spirit that "新質生產力" encourages.

The convergence of supportive government policies, enabling technologies and collaborative efforts is a powerful drive that can propel the acceleration of innovation. I look forward to Hong Kong's success in developing a carbon neutral transport system in

a foreseeable future.

I hope you have a wonderful day and enjoy the event today. Thank you.