IMechE Symposium on Energy Use on
Liquefied Natural Gas, Hydrogen and Waste Recycle Energy
"Engineering the Society to Achieve Carbon Zero with Clean Energy"

10 March 2023

Fusion for a Zero Carbon Future

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Greeting

Good morning Ir Chris Chong (Chairman of IMechE Hong Kong Branch), Ir Edmund Leung (Chairman of Symposium Steering Committee), distinguished guests, ladies and gentlemen.

It's my great pleasure to join the symposium today, and I'd like to thank the IMechE Hong Kong Branch for giving me this interactive platform to share innovative ideas and technological advancement on energy use.

Introduction

The theme of this symposium is **"Engineering the Society to achieve Carbon Zero with Clean Energy"**. In fact, it echoes with the Hong Kong's pledged target for achieving carbon neutrality before 2050. The **three types of gas, namely LNG, hydrogen and biogas,** covered in today's symposium have been playing specific roles in the four major decarbonization strategies as set out in the Hong Kong Climate Action Plan, which are **"net-zero electricity generation", "energy saving and green buildings", "green transport" and "waste reduction"**.

To begin with, let's have a glance on **mankind's energy evolution history**. Our ancestors started getting energy by burning woods and then progressing to coal, oil and natural gas throughout the 19th century. In recent years, renewable energy has been the talk of the town. Along the journey in the evolution of energy sources, there is no doubt that they all originate from **"The Sun", the ultimate source of energy for every life on Earth.**

Even under this great technology era, the Sun is still one of the major areas of study because of its infinite source of energy. An **artificial sun**, which can create a safe and clean energy source by nuclear **fusion,** has long been a dream for scientists. While an IMechE Report on **Fusion Energy**[1] is expecting nuclear fusion to be crucial in the low-carbon economy and will be a key part of the post-2040 electricity generating mix, researches on nuclear **fusion** have shown a huge breakthrough lately with the experimental success from China, US and other countries. Though the use of **fusion** power may remain far from us, **there are indeed other forms of fusion[2] in my mind** which I would like to share with you today on how they could be integrated towards the Zero Carbon target.

The Fusion of "Increase" and "Decrease"

The alternative concept on fusion in my mind is about "Increase" and "Decrease". This may seem a bit contradictory but "Increase" and "Decrease" actually go quite well with each other in our case. On one hand, while we keep on **increasing the choice of cleaner energy supply** like Liquefied Natural Gas (LNG), Renewable Energy (RE) and Hydrogen; on the other hand, we strive to **decrease the energy demand and waste disposal** at all levels.

In 2021, the **global CO_2 emission** from energy combustion and industrial processes recorded an ever highest annual level at 36.3 Gigatonnes (Gt), with a record 10.5 Gt from coal power plants emissions[3].

Electricity generation is the largest contributor to carbon emissions in Hong Kong, accounting for **over 60%** of the total carbon emitted in 2020. As contrasted to coal firing power generation, natural gas for power generation produces only half of the CO_2 emission rate.[4] **Despite not carbon free, natural gas plays an important role in the transition to a Carbon Zero society** and its demand is ever increasing in recent years. Therefore, **the first step is to increase the use of natural gas for power generation in**

[1] "Fusion Energy: A Global Effort – A UK Opportunity" (https://www.imeche.org/docs/default-source/1-oscar/reports-policy-statements-and-documents/imeche-fusion-report-ao.pdf?sfvrsn=a9a29112_2)

[2] Definition of "Fusion" by Cambridge Dictionary – An occasion when two or more things join or are combined (https://dictionary.cambridge.org/dictionary/english-chinese-traditional/fusion)

[3] https://www.iea.org/reports/global-energy-review-co2-emissions-in-2021-2

[4] https://www.gasvessel.eu/news/natural-gas-vs-coal-impact-on-the-environment/#:~:text=Natural%20gas%20is%20a%20fossil,a%20typical%20new%20coal%20plant.

Hong Kong.

Increasing LNG supply diversity and reliability with HK's first Offshore LNG Terminal adopting FSRU technology

To attain supply reliability and diversity of natural gas for power generation in Hong Kong, the CLP and HKE have deliberated with the Government and proposed the development of **an offshore LNG terminal using Floating Storage and Regasification Unit (FSRU) technology** in 2019. The offshore LNG terminal presents a viable gas supply option that will **enhance energy security through access to competitive gas supplies from world markets**.

Credits shall be given to all engineers and stakeholders contributing to this mega project, bringing this **first offshore LNG terminal in Hong Kong and China** into reality. With storage capacity of 263,000 m^3, the FSRU vessel could supply natural gas to both power companies for **up to about 20 days without replenishment.** With joint efforts from the government and the two power companies, I am delighted to learn that this terminal will be put into operation in the later half of this year. By then, it will be the **4th largest terminal in the world** among the 32 offshore terminals now operating globally[5]. I understand that the CLP and HKE will share with us more on this project in today's symposium. So please stay tuned for their interesting and informative technical details on the project.

"Increasing" – Renewable Energies (RE)

Even with the use of more natural gas for power generation, renewable energy (RE) is a better solution for reducing carbon emission in power generation to help achieve carbon neutrality. Therefore, **the second step is to increase the use of RE in Hong Kong**. A wide range of projects have been embarked on in Hong Kong to install RE in **reservoirs, restored landfills, government buildings and other suitable facilities**, aiming to **increase the share of RE to 7.5 to 10% by 2035**. Not only does the Government take the lead to do so, we also create favorable conditions for the private sector to install RE facilities in their premises. Supported by the two power companies, the **Feed-in Tariff**

[5] World LNG Report 2022, International Gas Union

(FiT) Scheme, together with a series of supportive measures, such as relaxation of the requirements for village houses rooftops, have already attracted over 20,000 applications and is estimated to meet the annual electricity demand of about 90,000 households upon completion of these systems[6]. On the other hand, various measures such as gross floor area concessions and fast-track mechanism for processing building plan submissions have been implemented to facilitate the installation of solar PV systems in open car parks in non-domestic premises. With Government's facilitation to the private sectors, we are looking forward to seeing more RE facilities to be commissioned in private sectors' premises in the near future.

In parallel, the government launched the **Solar Harvest Scheme** to fund and install more than 450 solar energy generation systems for schools and welfare NGOs, generating over 4 million kWh per year. In addition, the EMSD, in collaboration with the Environment and Ecology Bureau (EEB) and the Education Bureau (EDB), has launched a set of educational kits for primary schools to **support STEAM[7] education in schools**, to raise students' interest in science learning and their awareness of renewable energy and climate change, creating a favorable environment for the **fusion** of the whole community's joint effort on adoption of RE.

"Increasing" - Hydrogen as "new zero-carbon" energy

Use of hydrogen as a fuel has become a "global interest" in the "shift towards a clean energy" era. According to the International Energy Agency's (IEA) Global Hydrogen Review 2022[8], 25 countries, plus the European Commission, have released national hydrogen strategies as a clean energy vector in their clean energy transition plans.

The **Mainland China**, being the largest hydrogen producer with about 33 million tonnes annual production, has also revealed its vision towards hydrogen in the **14th Five-Year Plan**. Clean hydrogen is considered an important step in the country's stride towards its climate goals. According to the Long-Term Development Plan for Hydrogen Industry (2021-2035) announced in March 2022, China would **produce 100,000 to 200,000 tonnes of renewable-based hydrogen annually** and will have a fleet of **50,000**

[6] https://www.info.gov.hk/gia/general/202204/26/P2022042600448.htm

[7] STEAM (Science, Technology, Engineering, the Arts and Mathematics) Education Kit (https://re.emsd.gov.hk/english/gen/4S/4S_Education_Kits.html)

[8] https://www.iea.org/reports/global-hydrogen-review-2022

hydrogen-fueled vehicles by 2025. When this target is achieved, it is estimated that the country's carbon emission will be reduced by one to two million tonnes annually.

More than a hundred (100) pilot and demonstration hydrogen projects worldwide are underway, including the **world's first hydrogen-powered tram in China, first fleet of hydrogen fuel cell trains in Germany** and the **first shipment of liquefied hydrogen from Australia to Japan** [9] in February 2022. This bulk transportation of 1,250 m^3 of super-cooled (-253°C) liquid hydrogen is expected to boost up the international trade of hydrogen and is a breakthrough to hydrogen transportation beyond the constraints of tube trailers and pipelines.

According to the Hydrogen Council[10], the global capacity for green hydrogen production via water electrolysis is about 550 MW. China is currently the leader for green hydrogen production through electrolysis with the installed capacity at about 200 MW. The **150 MW plant in Ningxia,** which first come into operation in April 2021, is also labeled as the **world's largest green hydrogen electrolyser**.

Hence, **the third increase of clean energy source is to explore the use of hydrogen as fuel in Hong Kong**. Hong Kong has an unique advantage on geographic and regional collaboration with the Greater Bay Area (GBA) in establishing the hydrogen supply chain. The Guangdong Province can produce and supply hydrogen to Hong Kong. As for **Towngas**, the **3,600 km extensive piping network** in Hong Kong is already capable of **delivering town gas with about 50% of hydrogen** in its composition at present, which is higher than many trial projects in other countries in which only 10 to 20% hydrogen is blended in their natural gas pipework. This gives us a head start in exploring the future hydrogen pipeline transmission. Here we can see another form of **fusion** combining our geographical advantages and edge in existing infrastructure in propelling hydrogen development in Hong Kong.

Hydrogen as "new zero-carbon" energy

Hydrogen offers more benefits apart from zero-carbon emission. **The high efficiency of hydrogen fuel cell vehicle, or HFC vehicle in short, could save more energy and so**

[9] https://www.offshore-energy.biz/suiso-frontier-brings-worlds-1st-lh2-shipment-to-japan/

[10] https://hydrogencouncil.com/wp-content/uploads/2022/09/Hydrogen-Insights-2022-2.pdf

reduce the hydrogen demand. According to the U.S. Department of Energy (DOE)[11], a HFC vehicle is more efficient than an internal combustion engine running on gasoline by travelling longer distances with less energy. A fair deduction could be made with 1 kg of hydrogen and a gallon of gasoline containing about the same amount of energy. A HFC vehicle can run approximately 96 km[12] with 1 kg of hydrogen, compared to 40km on a gallon of gasoline for conventional vehicles. **HFC vehicles could thus be two times more energy efficient than conventional gasoline vehicles.**

As stated in the Climate Action Plan and Policy Address 2022, our government will collaborate with stakeholders to roll out the **HFC vehicles trial scheme**, aiming to cover both buses and heavy-duty vehicles like refuse collection trucks. An **Inter-departmental Working Group on Using Hydrogen as Fuel (IWGUHF)** was established in 2021 to create **fusion** of the expertise and efforts from various Departments to handle the trial applications of hydrogen in Hong Kong. EMSD, as the Gas Authority in Hong Kong and a key member of the working group, is dedicated to provide the professional inputs in the trial. We have been actively collaborating with franchised bus companies and other stakeholders to put forward the trials of HFC buses and heavy-duty vehicles.

While hydrogen could be a potential carbon-free game changer, there are many **safety concerns on its usage as fuel**. With wider flammability range, higher operating pressure and lower ignition energy as compared to fossil fuel, one must not overlook the potential risks brought about by hydrogen. Therefore, a holistic review on existing hydrogen regulation and **a new regulatory framework** are both crucial to pave the way for future legislation on hydrogen as fuel. In this connection, EMSD has launched **consultancy studies** from Q4 2022 to **develop suitable risk assessment methodology and safety standard for the use of hydrogen as fuel in Hong Kong**.

To appreciate the global HFC vehicles development and technology advancement, **two joint departmental technical visits to the Europe** was arranged by EMSD in October 2022 and February 2023. Apart from visiting the HFC double decker buses, hydrogen filling stations and the on-site hydrogen production facilities, the delegation gained insights on the planning, legislations, standards and practices of hydrogen, which are conducive to the implementation of the HFC vehicles trial scheme in Hong Kong. With the lift of the travel restriction, more visits to overseas, as well as the Mainland China,

[11] https://afdc.energy.gov/fuels/hydrogen_basics.html

[12] https://www.energy.gov/eere/vehicles/articles/hydrogens-role-transportation

are in the pipeline.

"Decreasing" landfill disposal with Waste-to-Energy projects

Apart from increasing the clean energy sources, decreasing the waste to be disposed in our landfill sites is also equally important. In Hong Kong, about **16,000 tonnes of solid waste** is produced every day, among which **3,600 tonnes of food waste** is generated daily, which is equivalent to the weight of 20 million apples. While the government has devoted great effort to promote the four Rs (Reduce, Reuse, Recycle and Recover), the solid and food wastes will soon saturate our three landfill sites. **Turning waste into energy is a win-win situation for reducing waste disposal to landfill sites and providing additional energy supply.**

As there are many environmental and land constraints to build new landfill sites, we have started developing waste to energy facilities in the past years. Commissioned in 2018, the **Organic Resources Recovery Centres Phase 1 (O.Park 1)** at Siu Ho Wan, Lantau Island is the only food waste processing plant in Hong Kong for now. Adopting anaerobic digestion technology, food waste is safely converted to biogas, a synthetic natural gas which is a sustainable for heat and electricity generation. The Centre can handle **200 tonnes of food waste daily** for **in-situ power consumption** as well as **electrifying 3,000 households via the main power grid**[13].

Another way to treat food waste is the **co-digestion of food waste with sewage sludge**, which have been in use at the Tai Po sewage treatment plant since 2019. Pre-treated food waste is anaerobically co-digested with sewage sludge to generate biogas, producing electricity to support the plant operation.

Looking slightly further ahead, the **heat recovered from incinerating solid waste at the Integrated Waste Management Facilities Phase 1 (I.Park 1),** would **produce about 480 million kilowatt-hours of electricity for the use by 100,000 households in Hong Kong every year**[14]. The plant is situated at Shek Kwu Chau (石鼓洲) and will be commissioned in 2025. Preliminary studies for the Phase 2 development of these biogas and incineration facilities are underway to enhance the waste handling capacity.

[13] https://www.opark.gov.hk/en/index.php

[14] https://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_IWMF.html

Decreasing" Energy Demand – Promoting Energy Efficiency and Conservation

Other than utilizing hydrogen as fuel and adopting waste-to-energy, the most effective and direct way to achieve carbon zero is to **reduce energy consumption in the demand side**. Buildings account for about 90% of Hong Kong's total electricity consumption. A clear target has therefore been set by the Government to **reduce the electricity consumption of new and existing commercial buildings by 30 to 40%, and that of residential buildings by 20 to 30% by 2050** (using the operational conditions of 2015 as the comparison basis).

In refining our energy saving strategies, a multi-pronged energy conservation approach is taken. On top of the current legislations on energy performance of buildings and appliances, we promote the **fusion** of community efforts and adoption of innovative ideas and advanced technology into existing E&M facilities to seize the decarbonization opportunities in buildings. We have also been encouraging and guiding the public to support and live in an energy-saving, waste-less and low-carbon lifestyle. Meanwhile, EMSD **has been applying "Semantic AI" on building operation and system optimization** to forecast cooling demand of air-conditioning systems and to optimize equipment performance for energy saving. The Semantic AI technology won a Gold Medal in the International Exhibition of Inventions of Geneva in 2021. In the West Kowloon Government Offices, the Semantic AI achieved a 99% accuracy in predicting the cooling demand, bringing 10 to 15 % improvement in plant energy performance and hence contribute to carbon neutrality. To further unleash the potential of AI in E&M installations, the EMSD established the **"E&M AI Lab"** in September last year as a collaborative international platform to accelerate effective partnerships in support of the big data and AI development on building E&M facilities.

What's Next?

To many of us, achieving carbon neutrality before 2050 is an ambitious target. We all wonder if there is any R&D or breakthrough worldwide that could give us insights to map out the next step for zero carbon? What could be done further on the hydrogen as fuel regime? Can we turn waste into hydrogen just like the biogas production?

In China, a project by a national chemical engineering company (CNCEC (China

National Chemical Engineering Co. Ltd.)) was completed in 2021 to showcase the **production of hydrogen from municipal waste at high temperature[15].** The hydrogen produced can then be "absorbed" by liquid organic hydrogen carrier to become a kind of "hydrogen oil", which can be easily transported to hydrogen filling station for refueling. Besides, **a China based oil company (Sinopec) will commission a green hydrogen production plant powered by a 300MW solar farm in Xinjiang** this year[16], which will outrank the plant in Ningxia as the world's largest. In tandem with the pace in decarbonization, our government is also exploring the installation of **floating solar panels at reservoirs for green hydrogen production**.

Closing

Scaling up the production of green hydrogen is our ultimate goal, but at the same time, we also need a sustainable source of baseload energy fuel to cope with our energy demand. Nuclear fusion may fill in this void by being a safe, plentiful and environmentally friendly source of energy. **Although the fusion technology may still be far from maturity, the collaboration of government, private sectors and the whole community, as well as the coupling effect of "increase" and "decrease" on energy supply and demand are surely other forms of fusion that could shed lights on our decarbonization journey.** We should continue to maximize the use of renewable energy, explore alternative fuel sources and strive to improve energy efficiency to ensure the best utilization of energy.

Carbon neutrality is not a mission impossible so long as everyone of us contributes to the vision. Let's join hands together to embrace the new projects, infrastructure, technological and regulatory breakthroughs in this carbon neutrality era.

Thank you very much.

[15] https://www.hynertech.com/en/nd.jsp?id=154#_jcp=1

[16] https://balkangreenenergynews.com/chinas-sinopec-building-worlds-biggest-green-hydrogen-factory/