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Challenges for Future-Proof Power Systems in the Digital Era
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Future Frontiers: Carbon-Neutral Pathway to Power System Transition

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Good morning Chairman, distinguished guests, ladies and gentlemen,

It is my great pleasure to address such a distinguished audience today on the very important topic of carbon neutrality and what it means to the future of our power systems. The Electrical and Mechanical Services Department is the safety regulator of power utilities and a driver of energy efficiency in Hong Kong, and as such, striving for carbon neutrality is at the core of our work. We would like to take this opportunity to visualise and explore, together with all the power industry experts and academia here today, how we can achieve carbon neutrality.

Regardless of where you come from, the signs of extreme weather are easily noticeable. Back in 2012, the year when I was a member of the organising committee of the eleventh IET Annual Power Symposium, Hong Kong's average temperature in May was only 27 degrees, according to the Hong Kong Observatory records. This year, we have just experienced the hottest May recorded in Hong Kong history, with an average temperature of 29 degrees, which was 2 degrees higher than in 2012, after only 9 years and despite all that we have done to tackle climate change.

The takeaway is that the challenge we face is much tougher than expected, and requires an even more aggressive and decisive approach to revert the deteriorating situation. Let's imagine, if climate change predictions and documentaries such as "The Inconvenient Truth" were true, we should be very worried about the possibility of sea level rising and storm surges which could flood and destroy major coastal cities like Hong Kong. Indeed, this very hotel and all our harbour front buildings will cease to exist in such catastrophes. The question is, what can be done to avoid the disaster?

IEA Report: Carbon Neutrality by 2050 and its Implications for Power Systems

The answer is carbon neutrality. The International Energy Agency (IEA) just published the "Net Zero by 2050" report last month. It outlines the roadmap to achieve global carbon neutrality by mid-century. The roadmap aims to limit the rise in global average temperature within 1.5 degrees above pre-industrial levels, which is the preferred option under the Paris Agreement of 2015. I would like to spend a few minutes to share with you its key insights and how we can help co-create and co-innovate a path towards carbon neutrality.

The roadmap rests on a projection that by 2050, the worldwide economy will double and the world population will boom by 25% compared with today, while sudden growth may imply that energy consumption including electricity consumption must inevitably increase, the IEA roadmap also says that global energy demand per capita must be reduced by approximately 30% in order to achieve net-zero by 2050. Interestingly, the IEA expects that the share of electricity in the world's energy mix will significantly increase from today's 20% to nearly 70% by 2050, meaning power systems everywhere in the world will take on a more vital role in global decarbonisation efforts.

If the above is not alarming enough, the IEA roadmap also expects all new buildings to be zero-carbon-ready by 2030, while all electricity generation is expected to have achieved net-zero emission globally by 2040. And by 2050, the IEA expects almost 70% of electricity will be generated by renewable sources. One of IEA's visions is that the rapid increase in electricity demand and the purposeful transition to clean, renewable energy will drive considerable expansion and modernisation of power systems around the globe. Transformation of the world's power systems will be a critical factor in achieving carbon neutrality, or net-zero.

Global Framework and Challenging Milestones

Luckily, the IEA roadmap does provide some pointers on how to achieve its carbon neutral targets. To achieve "net-zero", it believes that collaborative efforts from all parties will be required in two areas. First is to broaden the use of low-emissions energy resources. The second area is to apply more energy-efficient and electrification technologies.

Low-emissions Energy – Renewable Energy

The IEA report highlights a number of low-emissions energy that will play a key role in our way forward. One of the low-emissions energy is renewable energy, and the key is to replace 90% of fossil fuels uses in electricity generation with renewable sources at the global level. The percentage of renewables in global electricity generation was only 29% in 2020, but the IEA targets to increase this to over 60% in 2030 and 80% in 2040. One can only imagine the enormous effort required to ramp up the world's renewable energy installations on such a huge scale. Take wind and solar energy as examples. The annual capacity growth of wind and solar energy from 2020 to 2050 have to be five times higher than the average over the last three years in order to achieve these targets. Although the overall energy portfolio in Hong Kong is tiny compared with global consumption, our effort and performance are still important as one of Asia's world cities. As such, efforts by different sectors of our community to adopt renewable energy like installing PV panels or solar heating equipment in our buildings are encouraged and highly appreciated.

Low-emissions Energy - Bioenergy

Bioenergy is another form of low-emissions energy with good potential. Unlike traditional bioenergy, modern bioenergy including solid and liquid biofuels is clean energy harvested from sustainable sources and can play a key role in achieving net-zero emissions, while providing flexible low-emissions generation to complement generation from solar PV and wind. IEA anticipates that by 2050, electricity generated from bioenergy fuels will reach 5% of the total generation of about 3300TWh. In Hong Kong, bioenergy has been a part of electricity generation since the commissioning of the landfill gas power generation in West New Territories Landfill in 2020, a CLP facility with 10MW gross capacity. Under the "Waste Blueprint for Hong Kong 2035" published in 2021, the Government has developed different waste-to-energy facilities to convert sewage sludge, food waste and other solid wastes into electricity, including T·PARK and O·PARK1 which are already commissioned, as well as O·PARK2 and I·PARK which are under planning. These facilities are estimated to power over 100,000 households and will add variety to the city's clean energy portfolio. Nevertheless, to achieve net-zero target, these are not enough and we must find innovative ways to boost the use of bioenergy in electricity generation as well as the household and transportation sectors.

Alternative Fuel – Hydrogen

On top of renewable energy and bioenergy, hydrogen is attracting increasing attention as

an alternative fuel for gas-fired power plants, since hydrogen has the advantage of utilizing existing power transmission and distribution infrastructure. The IEA has estimated that the global use of hydrogen would increase from the existing 90Mt to more than 500Mt in 2050. By that time, over 60% of hydrogen will be generated by electrolysers, which is a process consuming a huge amount of electricity, hopeful this amount would be generated by renewable and other low carbon sources. The growing attention on hydrogen as an alternative fuel is one of the factors that will transform the world's power systems to accommodate hydrogen fuel and generate additional electricity from electrolysers to meet the enormous demand for clean electricity in future. The IEA also believes that world demand for hydrogen is likely to increase. This is echoed by, for example, the EU's hydrogen strategy to increase the annual production of green hydrogen, which is made from renewable energy, up to 10Mt by 2030. Now I turn to the second area in the IEA net-zero roadmap where collaborative efforts will be required, and that is how to use electricity more efficiently both in our existing facilities and also in the future massive electrification of existing non-electrical facilities in every sector of the global economy.

Energy Efficiency & Electrification

The IEA report states that global consumption of electricity will increase by 25% from 2020 to 2030, and double by 2050. Despite the expected massive adoption of clean energy sources, it will still be vital to focus on further improving energy efficiency on a global level. One very promising improvement in energy efficiency is the increasingly popular adoption of electric vehicles which consume 73% less energy than gasoline cars. But electric vehicles only make up part of the picture. In fact, the IEA roadmap has already outlined how different sectors can help achieve net-zero in the world. Let's take a closer look now.

We all know that in cities, buildings take up the lion's share of electricity consumption, therefore energy efficiency in both existing and new buildings have to be enhanced. For existing buildings, large-scale retrofitting programme is the solution to transform them into more energy efficient buildings, but the current rate of retrofitting is very slow even in developed economies. Indeed, it is IEA's target to see 50% of all existing buildings worldwide retrofitted to zero-carbon-ready levels by 2040. Meanwhile, for new buildings, the IEA also expects energy-related building codes to be introduced by 2030 to ensure that virtually all new buildings are zero-carbon-ready. Appliances used in buildings also

contribute to carbon emissions of the building sector. By the mid-2030s, the IEA expects that almost all household electrical appliances sold worldwide will be as energy efficient as the most efficient models available today. Its ultimate goal for the building sector is to increase the percentage of zero-carbon-ready buildings from less than 1% today to over 85% in 2050 -- a hugely challenging target for all of us!

Let's look at the transport sector, another major energy user which is heavily reliant on oil products. Currently, more than 90% of the transport sector uses oil products as fuel, a percentage that must drop to around 10% in 2050 according to the IEA roadmap. This explains why massive electrification of existing modes of transport is urgently needed. As the cost of battery continues to decline and governments around the world will incrementally place more stringent bans on vehicles with internal combustion engines (ICEs) by 2035, it is estimated that the percentage of electric vehicles in the total number of vehicles will rise from the current 1% to over 20% by 2030 and 60% by 2040. Other modes of transport such as railway have already undergone electrification in many countries. Railway is already one of the most energy-efficient and least carbon-intensive modes of mass transport, and is expected to be almost fully electrified by 2050. As for shipping and aviation, the two remaining modes of transport, full electrification may not be possible. However, it is still important they switch from fossil to cleaner fuels such as hydrogen or biofuel and become more energy efficient in their operations. Overall, the IEA target is to reduce global carbon emissions in the transport sector by 90% by 2050. In a nutshell, we can say that the lifestyle in 2050 would be drastically changed from what it is today. Electricity demand will be much greater; energy sources will become cleaner and more diverse; buildings, appliances and modes of transport will be highly energy efficient; and many more existing non-electrical facilities will have undergone electrification. So what will be the combined impact of all these on our power systems?

Transition Towards Net Zero

Under net-zero planning, the first change will be in power generation. Power systems around the world will see an increasing penetration of variable renewable energy in the electricity mix. Unlike conventional power plants which can be precisely scheduled, major renewable energy are non-dispatchable, thus posing challenges to the stability and security of power systems in future. Also, renewable energy are usually distributed in remote sites or load centres, creating potential problems for the capacity, protection and control of existing power systems. The second change to power systems is increasing

demand due to massive electrification of various facilities and devices such as the wider use of electric vehicles in future. In the UK alone, peak electricity demand could be 15-40% higher than existing level when electric vehicle adoption reaches 50%. The drastic change in load profile may cause vital problems to the distribution system in smaller regions. This means that the overall capability and capacity of electricity generation, transmission and distribution networks shall be expanded to cater for significant increase in load demand and major changes in load profiles.

Future of the Power Systems

To tackle all the above changes in generation and demand, future power systems must be more reliable, flexible and secure. The actual implementation may vary from one power system to another, subject to local conditions and the specific electricity mix. But in general, the key will be the energy storage systems and the full digitisation of power systems. For storage systems, the IEA has estimated that global energy storage capacity shall reach 3,100 GW by 2050 in order to achieve net-zero. With the rapid development of electric vehicle technologies, their batteries can also serve as potential energy storage with vehicle-to-grid capabilities. Besides EV, there are other forms of battery storage systems for example utility scale battery facility in South Australia using Tesla PowerPacks, which is being used to store energy and provide power during peak hours to relieve the burden on the grid or to reduce outages. Indeed, batteries are only one option in the next generation of electricity storage systems. As technology advances, more innovative forms of energy storage options will certainly emerge.

Digitisation is also vital to achieve intelligent control of the power system, enabling a high level of protection for bi-directional power flow, smart metering for a highly flexible and timely demand response scheme, and much more. Indeed, digitisation may take many different forms.

Germany for instance has begun to adopt the Virtual Power Plant (VPP) concept to integrate all their power plants, distributed generation systems, storage systems and flexible consumer systems into one virtual system managed on the Cloud. The VPP can provide higher efficiency by better generation dispatch as well as greater optimisation and flexibility by better demand response. That is just one example of how power systems can be digitised for optimal performance. Hopefully, all the world's power systems will be as smart and digital in future.

Nevertheless, digitisation of power systems also brings its own risks such as cyberattacks. The latest case involved a major US fuel pipeline company whose business was severely disrupted by cybercriminal attacks. That's why on the way to digitisation, we must not underestimate the challenge of cybersecurity and should devote adequate resources to ensure system safety and continuity.

Co-create and Co-innovate a Net Zero Future

Ladies and gentlemen, 2020 was a tough year for everyone due to the COVID-19 pandemic. Climate change and its consequences could be even more life-threatening than COVID-19 if we do not take immediate action against it. We have just heard how amazing the carbon neutrality vision can lead to such game-changing possibilities in the demand for electrification and clean electricity, with all the consequential changes in distributed generation, demand and power system infrastructure in future. This all sounds very challenging, but those who can ride on the change will also benefit from the enormous opportunities arising.

To make an analogy, the IET Annual Power Symposium has come a long way since its launch in 2001. If we look back at the earlier symposiums, many past visions that were considered at the time as too aggressive or mission impossible have now come true. The 2004 Symposium envisioned a digital power system, and in 2005 we asked the question whether green energy was for real or too idealistic. Today, not only green energy has become reality but is also seen to be the key to achieving net zero in electricity generation by 2040. When I participated in organising the 2012 Symposium, we explored technologies to achieve zero carbon buildings, which paved our way to adopt a highly ambitious target for new buildings to be zero-carbon-ready.

If a single Symposium in Hong Kong has envisioned and achieved so much, then a lot more can certainly be achieved with concerted global efforts. And if the present is the future of the past, then Hong Kong, which has achieved so much against all odds, must be confident in our ability to co-create a pathway for the future based on our shared goal for carbon neutrality. Yet, one must admit that IEA's target to achieve carbon neutral on a global level in 2050 is extremely challenging. But if we act fast, and join hands with all stakeholders to co-create and co-innovate, there is a good chance that our power systems can rise to the challenge, and that all our waterfront buildings and the beautiful Victoria Harbour will stay intact in 2050 and beyond.

May I add one final point before closing. This year marks the 25th anniversary of the Electrical and Mechanical Services Trading Fund, and it is timely to highlight our culture of collaboration with all our client departments, the trades and other stakeholders in co-creation and co-innovation. We appeal to your continued support in forging a future generation of power systems to help fight climate change, and in building a better Hong Kong.

Thank you.

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