As Electricity Demand Climbs Every Year, Which Development Paths Lead to Net-zero Carbon Emissions?

With the emergence of net-zero carbon emissions and generative AI, the rising electricity demand will also become a major, long-term global trend accompanying these two hotly debated issues. For many governments and corporations, satisfying their electricity demand while meeting policy mandates related to low carbon emissions or net-zero carbon emissions is now a huge challenge. According to data from the International Energy Agency (IEA), the total electricity consumption of data centers worldwide is forecasted to surpass 1,000 terawatt-hours by 2026. This amount is equivalent to the annual electricity consumption of Japan. Additionally, with the electrification of vehicles and decarbonization of industries being irreversible long-term trends, electric vehicle sales are forecasted to account for 67% of total car sales by 2030. Hence, these projections indicate that global electricity consumption will continue to increase in the future. TrendForce analyst Danis He stated that in the future,

the share of renewable energy in electricity generation will continue to expand. However, no single generation technology can meet much of the electricity demand. Therefore, the ultimate goal of green energy transition is to establish a "stable, low-carbon power infrastructure" that requires multiple sources of energy technologies working in sync.

So, in terms of power infrastructure planning, how can governments and businesses simultaneously meet the rising electricity demand while also meeting requirements related to low carbon emissions and non-carbon energy?

He pointed out that currently, the costs of solar photovoltaics and   have significantly dropped, making them even more competitive against traditional coal-fired power stations. Consequently, many countries have been able to scale up their deployment of renewable generation systems and advance numerous clean energy projects. Even though solar photovoltaics and

and wind power are intermittent energy sources, they can play a vital role in stabilizing the operation of a power grid by coupling with lithium-ion battery energy storage systems, the costs of which have also fallen considerably in recent years. Additionally, redox flow batteries are also an option, especially for applications that require long-term energy storage.

Global Top 10 Photovoltaics Companies Are Based either in China or the United States as They Control Key Technologies and Huge Market Shares

Photovoltaic systems generally have relatively low installation requirements and will produce electricity as long as they are exposed to sunlight. Hence, they are widely deployed for various applications such as rooftop solar, ground-mounted photovoltaic installations, and floating photovoltaic installations. He stated that some manufacturers of photovoltaic products have already established carbon-neutral manufacturing processes. Under this premise, solar photovoltaics can be regarded as being far less polluting compared with other energy sources.
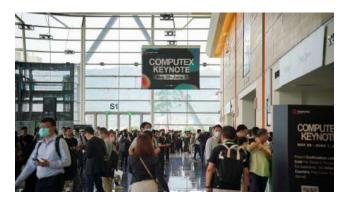
Presently, there are two types of silicon wafers used in the manufacturing of photovoltaic cells: N-type and P-type. N-type tunnel oxide passivated contact (TOPCon) cells have emerged as the market mainstream, and their demand is expected to soar in 2024. Approximately 57% of the total worldwide production capacity for photovoltaic cells is allocated to N-type TOPCon cells. P-type passivated emitter rear contact (PERC) cells have secured second place with around 32% of the total production capacity. He asserted that in terms of rankings of cell manufacturers based on production capacity and shipment volume, the trend of the strong getting stronger is increasingly evident. The market shares of the leading manufacturers have remained roughly the same compared to 2023. While the rankings of the top 10 have seen some minorchanges, the order has generally been constant. This group includes companies such as Canadian Solar,

LONGi, Jinko Solar, Trina Solar, and JA Solar, all based in China, as well as US companies such as First Solar.

In recent years, the government of Taiwan has been actively promoting initiatives related to green energy transition. Major photovoltaic companies in Taiwan include TSEC, URE, Motech, and Anji Technology. Currently, they are expanding their presence from the upstream sections of the supply chain, such as photovoltaic cells and modules, to the downstream sections, such as investments in photovoltaic power stations.

Synergy of Various Low-carbon Energy Sources Has Revealed a Promising Future for Hydrogen and CCUS

There are countless types of renewable energy available today, including many that are specific to different environments and geographical conditions, such as tidal power and geothermal energy. These energy sources primarily target niche markets, and widespread commercialization is still far off for them. However, for countries that possess abundant geothermal resources or other geographical advantages, such as being surrounded by the ocean, they ultimately have ample natural resources that can be utilized for renewable generation.

Since geographical environments differ from region to region, the deployment of electricity generation systems must consider various factors in order to

2023 COMPUTEX Keynote attracted a large crowd of attendees.

realize the full-scale adoption of low-carbon energy. Nevertheless, several newly emerged energy sources have generation costs that are still significantly higher compared to traditional fossil fuels. Among these emerging energy sources, green hydrogen is highly anticipated to play a critical role in achieving net-zero carbon emissions. He said that while green hydrogen is very costly at this moment, it will undoubtedly become mainstream in the next decade or two, serving as a promising low-carbon energy source and an option for energy storage beyond 2030. According to the IEA's Global Hydrogen Review 2023, global hydrogen demand is forecasted to reach 150 million tons by 2030, and the total installed capacity of generation systems that consume either hydrogen or ammonia will exceed 5.8 gigawatts. Furthermore, this report states that in order to meet the 2050 net-zero target, hydrogen energy needs to account for at least 13% of the overall energy consumption.

The use of hydrogen fuel for transportation has been advocated by companies such as Air Liquide from France. Apart from collaborating with Toyota from Japan and Hyundai from South Korea, Air Liquide is also promoting the adoption of green hydrogen in Taiwan. Another example is the US-based GE partnering with TWAIDC to develop a generation unit that runs on both natural gas and hydrogen.

As for carbon capture, utilization, and storage (CCUS), cost is also a challenge at the current stage. In order to ensure a stable energy supply, the presence of thermal power stations that burn fossil fuels remains necessary, though these facilities need to undergo further transformation. He pointed out that against the backdrop of surging electricity demand, countries around the world are vigorously advancing towards renewable energy as they plan and develop power infrastructure. However, at the same time, new thermal generation units featuring some type of CCUS technology are also being developed.

CCUS has undergone several decades of development and is expected to become an indispensable part of our future energy system. In 2021, a Swiss startup named Climeworks activated the world's first facility for carbon capture and conversion. Capable of capturing 4,000 tons of carbon dioxide annually, this facility represents a milestone in the development of an industry for direct carbon capture. Also, in 2023, Microsoft signed a contract to buy "carbon removal credits" from another US company aptly named CarbonCapture. Having developed a process that removes carbon dioxide from ambient air and stores it underground, CarbonCapture assists Microsoft in eliminating its historical carbon emissions and achieving its carbon-negative goals.

Looking at Taiwan, major local producers of carbon emissions such as Formosa Plastics, Taipower, and CSC are now actively investing in the development of technologies related to CCUS. However, He said that at the current stage, implementing CCUS to reduce carbon footprints can incur a substantial cost and affect the efficiency of power generation. Studies have shown that coal-fired power stations that have adopted CCUS have seen a 60% increase in generation cost as well as a 20-30% reduction in generation efficiency. Moreover, Taiwan cannot replicate the arbitrary carbon storage methods used in the US and Europe due to its limited landmass. Without sufficient subsidies, CCUS cannot be applied on a large scale.

Integration of AI into Smart Grids Will Massively Boost Efficiency in Electricity Usage

As countries gradually proceed with the green energy transition, the market penetration rate of intermittent renewable energy sources climbs, while traditional thermal baseload power stations shut down. This trend has the effect of heightening uncertainty in the operation of power grids. Therefore, many new kinds of methods and energy sources have been developed to regulate the grid. Furthermore, the entire electric power system is inevitably advancing into the era of smart grids.

The purpose of the smart grid is to reduce electricity loss and effectively integrate renewable energy. To this

end, it is anticipated that technologies related to artificial intelligence (AI) will have an increasing presence in the field of grid operation. Presently, several Taiwan-based companies are involved in the downstream of the industry chain for smart grid, providing services for various applications. Among these players, Delta Electronics, Chung-Hsin Electric & Machinery, HDRE, Advantech, and Tatung System Technologies all provide system integration services. Furthermore, their solutions can leverage big data to improve generation efficiency and perform predictive analysis. For instance, by collecting and processing data related to weather forecasts and performances of individual generation units, an AI-enabled solution can predict the amount of electricity produced by a solar or wind project. Furthermore, these companies also provide hardware and software that enable real-time monitoring of the grid, providing indicators such as the quality of electricity supply, load, etc. Overall, their services and products can facilitate real-time power dispatching and optimization of the whole grid system.

Currently, AI cannot be extensively applied for grid scheduling. As He pointed out, in terms of legal responsibilities and obligations, if errors occur in power dispatching, it will be difficult to determine accountability. No sector within the entire electric power system are able to provide sufficient safety assurances or guarantees when it comes to adopting AI for certain applications. All in all, this is one of the major challenges in the future development of the smart grid.

COMPUTEX 2024 is scheduled to take place from **June 4th to 7th at the Taipei Nangang Exhibition Center Halls 1 and 2**. With the theme "Connecting AI," this year's exhibition will focus on showcasing the latest global AI technologies and industry trends. The event is expected to attract **1,500** international and local exhibitors, utilizing **4,500** booths across six major areas: AI Computing, Advanced Connectivity, Future Mobility, Immersive Reality, Sustainability, and Innovations. International **visitor registration opens in March**. Visitors from all industries are welcome to participate and experience Taiwan's exceptional AI strength.

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