Advancing Net Zero through carbon emission risk management with Hydrogen Power, Eco-architecture, Sustain-gineering

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Introduction

With the alarming hottest global average temperature record in 2020 by 1.02 degrees Celsius over 1951-1980 mean, aggressive reduction of carbon emissions to stop global warming has no room for delay. As over 60% of carbon emissions in Hong Kong are attributable to energy consumption for buildings, our team hereby uses Oxford House as a prototype and proposes advancing net carbon zero for commercial building through AI carbon risk management with Hydrogen power, Eco-architecture, Sustain-gineering. Those technologies aim to minimization of carbon emission without compromise in well-being of occupants.

Hydrogen Power

Majority of operational carbon footprint of Oxford House comes from grid electricity as the electric generation relies on combustion of coal and natural gas. In order to achieve carbon neutral, revolutionary replacement of grid electricity by hydrogen energy is proposed.

The adoption of hydrogen energy is hindered by issues of storage, transportation and distribution of gaseous hydrogen. However, by the advancement of nanotechnology, our silicon nanopowders can react with basic solution under moderate temperature to produce hydrogen at controlled and demanding manner. Ultra-pure hydrogen can be directly usable in fuel cell to generate electricity.

With 20-ft container of silicon, electricity generated is about 60,000 kWh which is sufficient for usage by Oxford House by 2 days. Unlike fossil fuel, combustion of hydrogen only produces unharmful water without release of greenhouse gas.

Besides, sodium silicate as by-product from hydrogen formation from silicon is a valuable material for constructional and industrial usage, like converting to sodium silicate for formulation of cements, passive fire protection, adhesives and silica gel.

Eco-Architecture

It is unrealistic to stop using the HVAC system completely, our modified building envelope in Eco-architecture include 5 strategies to intensify passive cooling such that energy consumption on cooling and ventilation could be minimized.

Open up the elevated circulation space – instead of providing HVAC to this indoor circulation space on the G/F and 1/F level, increase the permeability to enhance air circulation, create more shades by using less glass surfaces, plant more suitable species of plants along the perimeter of the space. All measures can contribute to the thermal comfort and human wellness.

Adaptive façade in providing shades and harvesting energy for the tower – heat gain through curtain wall contribute to higher demand in cooling load. Installation of deep architectural fins over the windows could reduce the direct sunlight from entering the interior. Addition of circulating water-fluid within insulating glazing unit could also further prevent unwanted heat gain.

Green and Blue roof – relocate HVAC condensers to one storey higher, such that main roof can be converted to a green garden accessible to the tenants and heat gain from the roof could be diminished by plantation.

Spatial optimization and adjustable indoor comfort – Through increased mobility of working desktops with localized adjustment of HVAC, occupants are settled at locations with optimized indoor comfort with minimal cooling energy required.

Sustain-gineering

The purpose of Sustain-gineering was to adapt the latest engineering technologies through 4 major strategies covering renewable energy sources and energy efficiency to achieve carbon neutral for Oxford House.

Solar Power Wall - With significant areas on South and East side coinciding with sunshine path, extensive PV Solar Panel with matching design of current façade can be installed from the 21st to 40th floor to deliver 120 kWh annual electricity energy under approximation of 1800 annual sunlight hours.

Water Mist Spray Cooling - As the Ground and 1st Floor will be opened for passive cooling, a Water Mist Spray Cooling System in operation with natural draft and electric fan would enhance the user comfort at this open space by inducing temperature drop of 3 – 8°C.

Pre-dry Outdoor Air - Dehumidifier can be installed in every floor before external air entering the AHU, such that relative humidity between 40% and 60% provides the best comfort to human body with higher set point temperature allowable.

Piezoelectric Human Power - Piezoelectric Human Power was to encourage the aware of healthy lifestyle and conservation of energy. All tenants and visitors of the Oxford House contributes to the generation of green energy by walking on the piezoelectric tile paved on the Ground, 1st Floor and the lift lobby of every floor.

AI carbon risk management

The conditions of the building are continuously monitored by sensors covering the measurements from energy to well-being, including electricity, air, temperature, humidity, light, people, micro-organisms, water, and waste. Risk matrix of Advancing Carbon Net Zero evaluate the risk through 3 factors: Carbon Emission, Health & Safety, Comfort, such that minimization of carbon release in balance with well-being of building users.

Carbon Emission Risk - measured by energy use intensity and portfolio of energy sources. Threshold risk levels are set in consideration of location, season and time, to provide the benchmark of carbon emission levels for various facilities.

Health & Safety Risk - determined by parameters in ventilation per person, micro-organisms and air pollutants, the corresponding risk thresholds are referenced to ASHARE and HK indoor IAQ guideline.

Comfort Risk – determined by parameters in temperature & humidity, light and occupants' density in accordance to ASHARE, IES and CIBSE standards.

AI model can identify the zones with low risks in Health & Safety and Comfort with potential reduction in Carbon Emission, like localized adjustment of HVAC, migration of working desks to optimal zones for tenants and shifting energy source to cleaner energy like Solar Power.

Estimated Carbon Reduction

With the mentioned technologies on reduced reliance on energy, the annual estimated electricity intensity by Oxford House would decrease from 131.9 kWh/m^2 in 2019 to 98.4 kWh/m^2 by 2050.

Furthermore, with replacement of grid electricity by Hydrogen Power, Solar Power and Piezoelectric Walking Power, the annual operational carbon emission intensity of Oxford House could change from 79.15 to 9.54 kg CO_2-e per m^2.

Conclusion

With introduction of innovative energy sources and building engineering with AI risk management, advancing to carbon neutral is balanced with well-being of building users.